WEBVTT

1 00:00:00.760 --> 00:00:05.570 - Hi everyone, welcome to our second seminars

2 00:00:05.570 --> 00:00:07.184 in this fall.

3 00:00:07.184 --> 00:00:11.753 This belongs to our Climate Change and Health Center

4 00:00:13.360 --> 00:00:16.570 four seminar series on climate change and health

5 00:00:16.570 --> 00:00:21.570 and today we're very fortunate to have Dr Virginia Pitzer.

6 00:00:22.690 --> 00:00:25.480 She's an Associate Professor of Epidemiology

7 00:00:25.480 --> 00:00:29.100 from the Microbial Disease Department.

8 00:00:29.100 --> 00:00:34.100 So she's also one of our pilot project awards winners.

9 00:00:35.280 --> 00:00:37.350 So her research mainly focused

10 00:00:37.350 --> 00:00:40.410 on the new mathematical modeling

11 00:00:40.410 --> 00:00:45.410 of the transformation dynamics of infectious diseases.

12 00:00:45.410 --> 00:00:48.120 So without further ado,

13 00:00:48.120 --> 00:00:50.663 the floor is Gina Pitzer.

14 00:00:51.890 --> 00:00:54.050 - Well thanks very much for the introduction

15 00:00:54.050 --> 00:00:57.543 and hopefully we can switch to my screen.

16 00:00:59.205 --> 00:01:01.760 I think you need to enable share screen,

17 00:01:01.760 --> 00:01:02.923 screen sharing for me.

18 00:01:13.150 --> 00:01:15.990 - Just a general reminder to everyone

19 00:01:15.990 --> 00:01:17.900 that you should mute yourself

20 00:01:17.900 --> 00:01:19.890 if you are not asking questions.

21 00:01:19.890 --> 00:01:23.063 So we will be greatly appreciated.

22 00:01:27.520 --> 00:01:29.900 - Gina, I think you're good to go.

23 00:01:29.900 --> 00:01:30.733 - Got it.

24 00:01:42.490 --> 00:01:45.043 Okay, can everyone see the presentation now?

25 00:01:47.380 --> 00:01:50.330 Okay, well thanks very much for the introduction

26 00:01:50.330 --> 00:01:54.590 and for the opportunity to speak with you all today

27 00:01:54.590 --> 00:01:55.870 and so as Kai said,

28 00:01:55.870 --> 00:01:59.240 I'm gonna be talking about some of the ways

29 00:01:59.240 --> 00:02:01.600 in which we use different models

30 00:02:01.600 --> 00:02:05.760 as well as our mechanistic understanding of relationships

31 00:02:05.760 --> 00:02:09.040 in order to predict the impacts of climate change,

32 00:02:09.040 --> 00:02:12.173 specifically for infectious diseases.

33 00:02:13.700 --> 00:02:16.180 And so when it comes to predicting the impacts

34 00:02:16.180 --> 00:02:19.430 of climate change on infectious diseases,

35 00:02:19.430 --> 00:02:21.140 often the way that this is done

36 00:02:21.140 --> 00:02:23.357 and let me see if I can get this working,

37 00:02:28.900 --> 00:02:33.900 is to take a model of climate projections over time

38 00:02:34.370 --> 00:02:38.557 and for example this is projections around variations

39 00:02:39.840 --> 00:02:44.840 in temperature from the current day up through 2100

40 00:02:48.520 --> 00:02:51.060 and to combine this with a model

41 00:02:51.060 --> 00:02:55.350 for the incidence of disease given climate

42 00:02:55.350 --> 00:02:59.336 and use this to get projections of the relative risk

43 00:02:59.336 --> 00:03:03.787 of different diseases over time and for example this is data

44 00:03:05.720 --> 00:03:09.730 on model projections of the relative risk of diarrhea

45 00:03:09.730 --> 00:03:12.920 over time given the model forecast

46 00:03:12.920 --> 00:03:16.250 for increases in temperature over time,

47 00:03:16.250 --> 00:03:21.000 suggesting that by 2010 to 2039,

48 00:03:21.000 --> 00:03:22.974 you should see a median increase

49 00:03:22.974 --> 00:03:27.974 or relative risk of around 1.1 and by 2040 to 2069,

50 00:03:29.410 --> 00:03:31.940 a relative increase, median increase

51 00:03:31.940 --> 00:03:36.940 of around a relative risk of 1.2 and upwards of 1.3

52 00:03:37.230 --> 00:03:42.230 by the 2070 to 2099 time frame

53 00:03:44.516 --> 00:03:48.450 and voila, I mean that's basically you know,

54 00:03:48.450 --> 00:03:51.910 one of the ways that people have gone about doing this.

55 00:03:51.910 --> 00:03:53.090 So you know, thank you.

56 00:03:53.090 --> 00:03:54.513 I'll take any questions now.

57 00:03:55.500 --> 00:03:57.900 But of course if it were as simple as that,

58 00:03:57.900 --> 00:03:59.700 this would be a very short talk

59 00:04:00.830 --> 00:04:03.460 and I'd argue that really the most difficult part

60 00:04:03.460 --> 00:04:08.050 of understanding the climate of this is

61 00:04:08.050 --> 00:04:11.550 really understanding the true climate disease relationship

62 00:04:11.550 --> 00:04:15.780 and in particular, the causal effects of climate change

63 00:04:15.780 --> 00:04:19.560 on infectious diseases which is really far

64 00:04:19.560 --> 00:04:23.350 from straight forward and typically cannot be determined

65 00:04:23.350 --> 00:04:26.300 by the simple regression type analyses

66 00:04:26.300 --> 00:04:29.050 that were used in that previous study

67 00:04:29.050 --> 00:04:31.900 and are often used in many types of analyses

68 00:04:31.900 --> 00:04:34.140 of relationships between climate

69 00:04:34.140 --> 00:04:37.653 and chronic diseases for example.

70 00:04:39.300 --> 00:04:41.490 And so I'd argue that in order

71 00:04:41.490 --> 00:04:46.490 to really have a true causal model for linking climate

72 00:04:51.360 --> 00:04:54.660 to infectious diseases, there are really three main criteria

73 00:04:54.660 --> 00:04:58.530 that are needed to be met and these include

74 00:04:58.530 --> 00:05:01.170 that the change in infectious disease incidents

75 00:05:01.170 --> 00:05:06.030 really must occur at the right time, in the right place

76 00:05:06.030 --> 00:05:11.030 and in the right direction in order to be causally linked

77 00:05:11.490 --> 00:05:14.240 to a change in climate

78 00:05:15.260 --> 00:05:18.500 and the last of these criteria

79 00:05:21.390 --> 00:05:24.600 really requires that you have a hypothesis

80 00:05:24.600 --> 00:05:28.640 about the mechanism through which climate impacts

81 00:05:28.640 --> 00:05:31.000 on infectious diseases.

82 00:05:31.000 --> 00:05:34.950 well the first tWo really involve the careful analysis

83 00:05:34.950 --> 00:05:36.860 of spatiotemporal data

84 00:05:38.350 --> 00:05:42.450 and so in this talk I'm really going to begin

85 00:05:42.450 --> 00:05:44.750 by talking about the mechanisms

86 00:05:44.750 --> 00:05:48.030 through which climate can have important impacts

87 00:05:48.030 --> 00:05:50.030 on infectious diseases,

88 00:05:50.030 --> 00:05:52.580 including both the direct effects of climate

89 00:05:52.580 --> 00:05:56.050 on infectious diseases as well as some of the indirect ways

90 00:05:56.050 --> 00:05:59.473 in which climate can impact on infectious diseases,

91 00:06:00.359 --> 00:06:05.359 and then I will talk about how we go about identifying

92 00:06:05.650 --> 00:06:07.540 and quantifying these associations

93 00:06:07.540 --> 00:06:10.560 between climate and infectious diseases,

94 00:06:10.560 --> 00:06:13.000 including the types of data that are often used

95 00:06:13.000 --> 00:06:15.910 to draw these associations

96 00:06:15.910 --> 00:06:18.490 and the various quantitative approaches

97 00:06:18.490 --> 00:06:22.550 that apply specifically to infectious diseases

98 00:06:22.550 --> 00:06:27.050 when trying to measure these associations

99 00:06:27.050 --> 00:06:30.453 between climate and disease transmission.

100 00:06:31.380 --> 00:06:34.960 And I'll largely be drawing on examples from my own work,

101 00:06:34.960 --> 00:06:35.793 particularly when talking

102 00:06:35.793 --> 00:06:38.440 about these quantitative approaches.

103 00:06:38.440 --> 00:06:40.677 And then finally I'm gonna end with just some challenges

104 00:06:40.677 --> 00:06:44.890 and some opportunities to really get further

105 00:06:44.890 --> 00:06:48.610 when it comes to making these predictions

106 00:06:48.610 --> 00:06:51.313 around climate change on infectious diseases.

107 00:06:52.999 --> 00:06:56.430 And so one of the main ways

108 00:06:56.430 --> 00:06:59.080 in which climate can have an impact

109 00:06:59.080 --> 00:07:03.790 on infectious diseases is through the effects of climate

110 00:07:03.790 --> 00:07:07.160 on pathogen survival and, or replication

111 00:07:07.160 --> 00:07:09.270 within the environment.

112 00:07:09.270 --> 00:07:14.270 And so one example here is work that's been done

113 00:07:14.370 --> 00:07:19.370 by researchers to understand the effects of temperature

114 00:07:21.140 --> 00:07:25.030 and humidity on the transmission of influenza

115 00:07:25.030 --> 00:07:26.960 where researchers use guinea pigs

116 00:07:26.960 --> 00:07:29.040 which are a great kind of model system

117 00:07:29.040 --> 00:07:31.820 for measuring influenza transmission,

118 00:07:31.820 --> 00:07:36.820 to examine how the level of transmission happened

119 00:07:37.450 --> 00:07:40.670 from an infected guinea pig to a susceptible

120 00:07:40.670 --> 00:07:44.700 and exposed guinea pig that was housed in a separate cage,

121 00:07:44.700 --> 00:07:49.259 but downwind of this infected guinea pig

122 00:07:49.259 --> 00:07:53.860 when they modulated the temperature

123 00:07:53.860 --> 00:07:58.120 and humidity of the cages

124 00:07:58.120 --> 00:08:00.670 in which these guinea pigs were housed.

125 00:08:00.670 --> 00:08:05.610 And generally what they found was that both survival

126 00:08:05.610 --> 00:08:08.910 and transmission of influenza virus was really enhanced

127 00:08:08.910 --> 00:08:13.800 at low temperatures and low relative humidities,

128 00:08:13.800 --> 00:08:16.850 and when colleagues went about and re-analyzed

129 00:08:16.850 --> 00:08:20.660 some of this data, what they were able to show was

130 00:08:20.660 --> 00:08:24.430 that it was really absolute humidity or vapor pressure

131 00:08:24.430 --> 00:08:26.400 which was even better at explaining

132 00:08:26.400 --> 00:08:28.470 some of these associations

133 00:08:28.470 --> 00:08:32.430 and in particular the combined effect of temperature

134 00:08:32.430 --> 00:08:37.430 and relative humidity and then based on this relationship,

135 00:08:39.390 --> 00:08:42.380 we were able to use some of this data

136 00:08:42.380 --> 00:08:46.953 and combine it with mathematical models of flu transmission

137 00:08:46.953 --> 00:08:50.140 to show that by incorporating the relationship

138 00:08:50.140 --> 00:08:54.310 between absolute humidity and flu transmission

139 00:08:54.310 --> 00:08:58.440 into these models, we could better forecast the timing

140 00:08:58.440 --> 00:09:03.440 of seasonal flu epidemics happening across the US each year

141 00:09:03.810 --> 00:09:07.540 where often the epidemic tended to be preceded

142 00:09:07.540 --> 00:09:10.370 by a dip in absolute humidity

143 00:09:10.370 --> 00:09:15.363 before each flu epidemic happening in each year.

144 00:09:17.230 --> 00:09:18.340 So another way

145 00:09:18.340 --> 00:09:22.510 in which climate might affect infectious disease incidents

146 00:09:22.510 --> 00:09:27.130 is through its impact on host defenses and host behavior

147 00:09:27.980 --> 00:09:31.294 and so you know, we've all been told to bundle up

148 00:09:31.294 --> 00:09:34.119 in the winter so that we don't catch a cold

149 00:09:34.119 --> 00:09:36.140 and of course we know that

150 00:09:36.140 --> 00:09:41.140 while we don't actually catch colds by being cold,

151 00:09:42.130 --> 00:09:46.430 there is actually some potential truth to this mechanism

152 00:09:48.440 --> 00:09:50.630 and so when it comes to colds

153 00:09:50.630 --> 00:09:55.487 which are caused by rhinoviruses as one example,

154 00:09:55.487 --> 00:09:58.860 it has been shown by work from Ellen Foxman

155 00:09:58.860 --> 00:10:02.260 and Akiko Iwasaka here at the med school

156 00:10:02.260 --> 00:10:07.260 that when the nasal cavities are exposed

157 00:10:08.690 --> 00:10:12.670 to warmer temperatures, they tend to exhibit higher levels

158 00:10:12.670 --> 00:10:16.240 of expression of Interferon gamma

159 00:10:16.240 --> 00:10:20.080 which is an important first line in defense

160 00:10:20.080 --> 00:10:25.080 against viruses such as rhinoviruses and other cold viruses.

161 00:10:25.450 --> 00:10:29.090 But these levels of Interferon gamma tend

162 00:10:29.090 --> 00:10:34.090 to be quite a bit lower when temperatures are lower,

163 00:10:34.770 --> 00:10:37.090 leading to potentially slightly impaired

164 00:10:37.090 --> 00:10:40.870 kind of first-line immune responses in the nasal cavities

165 00:10:40.870 --> 00:10:42.770 at colder temperatures

166 00:10:42.770 --> 00:10:46.440 which may be part of the reason why we do indeed tend

167 00:10:46.440 --> 00:10:51.373 to get colds more often during the winter season.

168 00:10:53.570 --> 00:10:58.570 And so another way in which climate can impact

169 00:10:59.340 --> 00:11:03.510 on infectious diseases is through its impacts

170 00:11:03.510 --> 00:11:06.816 on the risk of human exposure.

171 00:11:06.816 --> 00:11:08.820 And so for example it's known

172 00:11:08.820 --> 00:11:12.533 that flooding can increase the risk of exposure

173 00:11:12.533 --> 00:11:15.910 to various waterborne pathogens

174 00:11:15.910 --> 00:11:19.940 including Leptospirosis which is a febrile illness

175 00:11:19.940 --> 00:11:23.500 that's transmitted primarily through the urine of rats

176 00:11:23.500 --> 00:11:26.440 and so when you see these heavy rainfall events,

177 00:11:26.440 --> 00:11:30.607 often the rat urine can get washed into the street

178 00:11:33.020 --> 00:11:35.560 and into sewers where people are walking through

179 00:11:35.560 --> 00:11:40.411 and the bacteria can then enter into humans

180 00:11:40.411 --> 00:11:42.490 through small cuts on the feet

181 00:11:42.490 --> 00:11:45.134 when people are walking around in these floodwaters

182 00:11:45.134 --> 00:11:49.490 and mud that has been contaminated by this rat pee

183 00:11:49.490 --> 00:11:51.610 and this is something that has been studied

184 00:11:51.610 --> 00:11:56.610 by Albert Coe who's the department chair in EMD here

185 00:11:56.790 --> 00:11:58.290 at the School of Public Health

186 00:12:00.380 --> 00:12:03.980 and then finally for vector-borne diseases,

187 00:12:03.980 --> 00:12:04.813 it's very clear

188 00:12:04.813 --> 00:12:08.170 that climate can have really important impacts

189 00:12:08.170 --> 00:12:11.900 on the risk of disease often through its impacts

190 00:12:11.900 --> 00:12:14.496 on factors such as vector survival,

191 00:12:14.496 --> 00:12:17.555 vector fertility and development

192 00:12:17.555 --> 00:12:22.555 as well as the biting behavior of various vectors.

193 00:12:23.370 --> 00:12:26.770 And so this is why diseases like Dengue fever,

194 00:12:26.770 --> 00:12:30.040 Chikungunya and most recently Zika virus

195 00:12:30.040 --> 00:12:35.040 really tended to be confined primarily to the tropics

196 00:12:35.250 --> 00:12:39.353 since the adult Aedes aegypti mosquito

197 00:12:39.353 --> 00:12:41.591 as well as the Aedes albopictus mosquitoes,

198 00:12:41.591 --> 00:12:44.190 the survival of these mosquitoes is

199 00:12:44.190 --> 00:12:45.710 really temperature dependent

200 00:12:45.710 --> 00:12:47.930 and so at these warmer temperatures,

201 00:12:47.930 --> 00:12:49.840 they tend to live longer,

202 00:12:49.840 --> 00:12:54.840 allowing for the key time for these viruses

203 00:12:56.670 --> 00:12:59.740 to be acquired by the mosquitoes,

204 00:12:59.740 --> 00:13:03.380 develop within the mosquito gut and then be transmitted

205 00:13:03.380 --> 00:13:05.593 to a susceptible individual.

206 00:13:07.240 --> 00:13:10.310 Although these factors such as temperature

207 00:13:10.310 --> 00:13:12.290 really aren't the only factor that needs

208 00:13:12.290 --> 00:13:13.510 to be taken into account

209 00:13:13.510 --> 00:13:16.340 when predicting the risk of disease,

210 00:13:16.340 --> 00:13:19.730 since factors such as human behavior

211 00:13:19.730 --> 00:13:22.450 and the amount of time spent outdoors,

212 00:13:22.450 --> 00:13:24.650 housing development and whether or not there are screens

213 00:13:24.650 --> 00:13:28.340 on the windows and other actions that contribute

214 00:13:28.340 --> 00:13:31.890 to the prevention of mosquito breeding sites for example,

215 00:13:31.890 --> 00:13:33.990 can all play a really big role

216 00:13:33.990 --> 00:13:35.790 in the risk of vector-borne diseases

217 00:13:35.790 --> 00:13:38.840 across different climatic conditions

218 00:13:38.840 --> 00:13:40.863 and kind of across time.

219 00:13:42.900 --> 00:13:45.680 And another important factor is that

220 00:13:45.680 --> 00:13:50.680 while climate can affect the development rate of parasites

221 00:13:53.400 --> 00:13:56.410 and viruses within mosquito vectors

222 00:13:58.640 --> 00:14:03.100 and so for example the extrinsic incubation period

223 00:14:03.100 --> 00:14:08.100 of malaria often tends to be shorter at higher temperatures,

224 00:14:09.270 --> 00:14:10.630 another important factor which is

225 00:14:10.630 --> 00:14:15.280 often not necessarily taken into account is that variations

226 00:14:15.280 --> 00:14:17.840 around mean temperatures can also play

227 00:14:17.840 --> 00:14:20.570 a very important role.

228 00:14:20.570 --> 00:14:24.230 So it was found using experimental system

229 00:14:24.230 --> 00:14:26.900 that diurnal temperature variations

230 00:14:26.900 --> 00:14:30.080 or the variation in temperature between night and day

231 00:14:30.930 --> 00:14:33.422 really can play an important role

232 00:14:33.422 --> 00:14:38.422 in modulating both the development time of mosquitoes,

233 00:14:40.090 --> 00:14:43.580 the EIP as well as the survival rate of mosquitoes

234 00:14:45.140 --> 00:14:49.810 at different temperatures where at lower temperatures,

235 00:14:49.810 --> 00:14:53.360 larger diurnal temperature variations tended

236 00:14:53.360 --> 00:14:56.340 to increase the survival of mosquitoes

237 00:14:56.340 --> 00:14:59.100 and decrease the development time

238 00:14:59.100 --> 00:15:00.970 whereas at higher temperatures

239 00:15:00.970 --> 00:15:02.090 that tend to be you know,

240 00:15:02.090 --> 00:15:06.200 typically more conducive to survival of mosquitoes,

241 00:15:06.200 --> 00:15:07.440 when you take into account

242 00:15:07.440 --> 00:15:09.180 the diurnal temperature variations,

243 00:15:09.180 --> 00:15:11.560 it can actually lead to lower survival

244 00:15:11.560 --> 00:15:15.600 than might be predicted in a higher developmental time.

245 00:15:15.600 --> 00:15:17.740 And so you need to not only take into account

246 00:15:17.740 --> 00:15:18.770 just mean temperatures,

247 00:15:18.770 --> 00:15:22.570 but also often these variations in temperature

248 00:15:22.570 --> 00:15:23.683 around the mean.

249 00:15:26.540 --> 00:15:29.530 And then finally there are other both direct

250 00:15:29.530 --> 00:15:31.880 as well as indirect impacts of climate

251 00:15:31.880 --> 00:15:36.660 on infectious diseases and these include impacts of climate

252 00:15:36.660 --> 00:15:39.820 on the geographic range, population dynamics

253 00:15:39.820 --> 00:15:43.410 and behavior of zoonotic reservoir species

254 00:15:43.410 --> 00:15:46.108 as well as effects on human behavior

255 00:15:46.108 --> 00:15:49.250 such as seasonal migration that may be linked

256 00:15:49.250 --> 00:15:53.680 to agriculture and pastoralism that lead to kind of movement

257 00:15:53.680 --> 00:15:55.540 and aggregation of individuals

258 00:15:55.540 --> 00:15:58.040 in different areas at different times of the year.

259 00:15:59.490 --> 00:16:02.470 Finally, climatic events can cause displacement

260 00:16:02.470 --> 00:16:05.760 and aggregation particularly of climate refugees

261 00:16:05.760 --> 00:16:07.070 in different areas which can make them

262 00:16:07.070 --> 00:16:11.450 particularly vulnerable to various infectious diseases

263 00:16:11.450 --> 00:16:15.340 and then finally, climate can have important impacts

264 00:16:15.340 --> 00:16:18.170 on host susceptibility as we talked about earlier,

265 00:16:18.170 --> 00:16:19.830 but there are both climate related

266 00:16:19.830 --> 00:16:23.910 as well as unrelated causes of seasonal variation

267 00:16:23.910 --> 00:16:26.280 in host susceptibility

268 00:16:26.280 --> 00:16:30.730 for example linked to the length of day

269 00:16:30.730 --> 00:16:34.870 and how exposure to solar radiation can impact

270 00:16:34.870 --> 00:16:38.420 on vitamin D metabolism and such which plays an important,

271 00:16:38.420 --> 00:16:40.940 can be an important co factor in the immune system

272 00:16:42.810 --> 00:16:47.760 and so one of the ways in which we can identify

273 00:16:47.760 --> 00:16:51.590 and quantify the mechanistic impact of climate

274 00:16:51.590 --> 00:16:55.970 on infectious diseases is through experimentation

275 00:16:55.970 --> 00:16:58.340 and so for example, this is what was done

276 00:16:58.340 --> 00:17:00.890 with the guinea pig experiment that I talked about earlier

277 00:17:00.890 --> 00:17:02.977 where they looked at the effects of temperature

278 00:17:02.977 --> 00:17:05.623 and relative humidity on flu transmission.

279 00:17:07.227 --> 00:17:10.910 I also am showing here results of another experiment

280 00:17:10.910 --> 00:17:13.880 in which they looked at the effect of temperature

281 00:17:13.880 --> 00:17:18.260 on snail mortality which is an important host

282 00:17:18.260 --> 00:17:22.800 of Schistosomiasis and showed that the mortality rate

283 00:17:22.800 --> 00:17:24.740 of snails tended to be lowest

284 00:17:24.740 --> 00:17:29.740 when mean water temperatures were around 20 degrees Celsius

285 00:17:30.040 --> 00:17:31.980 in this experimental system,

286 00:17:31.980 --> 00:17:35.649 suggesting kind of the ideal climatic conditions

287 00:17:35.649 --> 00:17:39.740 for kind of greater survival of these snails

288 00:17:39.740 --> 00:17:41.470 which play an important role

289 00:17:41.470 --> 00:17:46.253 in the transmission cycle for Schistosomiasis.

290 00:17:49.450 --> 00:17:51.480 And another way to really identify

291 00:17:51.480 --> 00:17:54.743 and to quantify some of these mechanistic links

292 00:17:54.743 --> 00:17:58.910 between climate and infectious diseases is

293 00:17:58.910 --> 00:18:01.660 to use model-based approaches,

294 00:18:01.660 --> 00:18:04.910 but in this way, in this sort of fashion,

295 00:18:04.910 --> 00:18:07.890 it's really important to make sure

296 00:18:07.890 --> 00:18:11.330 that you're following supposed links

297 00:18:11.330 --> 00:18:13.570 within the causal pathway.

298 00:18:13.570 --> 00:18:17.060 And so for example, we have been working with researchers

299 00:18:17.060 --> 00:18:20.640 in Nepal based on some of the pilot funding

300 00:18:20.640 --> 00:18:21.473 that we received

301 00:18:21.473 --> 00:18:23.760 from the Climate Change and Health Initiative

302 00:18:23.760 --> 00:18:26.900 to try to quantify the impacts of rainfall

303 00:18:26.900 --> 00:18:30.470 on typhoid trans, typhoid fever transmission

304 00:18:30.470 --> 00:18:33.940 within the setting and to estimate the incidence

305 00:18:33.940 --> 00:18:36.260 of typhoid fever that might be attributable

306 00:18:36.260 --> 00:18:38.453 to rainfall in this setting,

307 00:18:39.520 --> 00:18:44.220 and you can see on the plot on the bottom left here

308 00:18:44.220 --> 00:18:47.710 that typhoid fever incidence tends to peak kind of

309 00:18:47.710 --> 00:18:50.440 during the rainy season within this particular setting,

310 00:18:50.440 --> 00:18:52.900 but there are also some of these important variations

311 00:18:52.900 --> 00:18:56.010 in seasonal incidents that are hard to explain

312 00:18:56.010 --> 00:18:58.393 just based on rainfall patterns alone.

313 00:18:59.630 --> 00:19:02.947 However, studies from our collaborators have shown

314 00:19:02.947 --> 00:19:07.947 that levels of bacterial DNA present in water sources

315 00:19:08.920 --> 00:19:13.230 in this region such as these wells that are often used

316 00:19:13.230 --> 00:19:18.200 by individuals to obtain water tend to,

317 00:19:18.200 --> 00:19:22.020 the levels of the bacterial DNA tend to be slightly higher

318 00:19:22.020 --> 00:19:25.100 following increases in rainfall

319 00:19:25.100 --> 00:19:27.183 or these big rainfall events.

320 00:19:28.420 --> 00:19:32.400 However when it comes to trying

321 00:19:32.400 --> 00:19:34.140 to quantify these associations

322 00:19:34.140 --> 00:19:38.307 between infectious disease incident and climate,

323 00:19:42.890 --> 00:19:44.950 there's a variety of different data types

324 00:19:44.950 --> 00:19:48.160 that are often used in order to do this

325 00:19:48.160 --> 00:19:51.230 and one of the most common types of data

326 00:19:51.230 --> 00:19:54.090 that is typically used to look at relationships

327 00:19:54.090 --> 00:19:57.860 between climate variables and infectious disease variables

328 00:19:57.860 --> 00:19:59.390 is data on seasonality,

329 00:19:59.390 --> 00:20:02.470 since often infectious diseases do exhibit

330 00:20:02.470 --> 00:20:04.983 these seasonal variations in incidents,

331 00:20:05.820 --> 00:20:09.002 however there often are a lot of things that vary seasonally

332 00:20:09.002 --> 00:20:10.880 and in these types of analysis,

333 00:20:10.880 --> 00:20:14.970 you need to be really careful to avoid confounding

334 00:20:14.970 --> 00:20:17.670 and just because things are correlated with each other,

335 00:20:17.670 --> 00:20:19.100 it doesn't necessarily mean

336 00:20:19.100 --> 00:20:22.180 that one thing is a cause of another.

337 00:20:22.180 --> 00:20:27.180 So for example, this is data on murders by steam,

338 00:20:27.700 --> 00:20:30.920 hot vapors and other hot objects in the US plotted

339 00:20:30.920 --> 00:20:32.680 in black here and the average age

340 00:20:32.680 --> 00:20:35.840 of the Miss America winner plotted in red

341 00:20:35.840 --> 00:20:38.850 which oddly enough are very highly correlated

342 00:20:38.850 --> 00:20:42.043 with one another, with a correlation coefficient of 87%,

343 00:20:43.280 --> 00:20:47.300 but I have a very hard time seeing how these,

344 00:20:47.300 --> 00:20:50.830 one thing could possibly be causally linked to another

345 00:20:50.830 --> 00:20:54.000 and so just because there are correlations present,

346 00:20:54.000 --> 00:20:55.474 doesn't necessarily mean that

347 00:20:55.474 --> 00:20:59.223 any of these correlations are necessarily causal.

348 00:21:00.900 --> 00:21:04.470 And so it's best if you can also link

349 00:21:04.470 --> 00:21:07.400 when looking at these seasonal relationships,

350 00:21:07.400 --> 00:21:10.320 link the between year variations in incidents

351 00:21:11.710 --> 00:21:15.590 and deviations from normal climatic conditions

352 00:21:15.590 --> 00:21:19.510 to anomalies in the infectious disease incidents.

353 00:21:19.510 --> 00:21:22.606 So for example, one of the things that we found

354 00:21:22.606 --> 00:21:27.520 in modeling the relationship between absolute humidity

355 00:21:27.520 --> 00:21:31.470 and influenza, seasonal influenza in the United States was

356 00:21:31.470 --> 00:21:33.960 that there tended to be these dips

357 00:21:33.960 --> 00:21:38.400 in the absolute humidity relative

358 00:21:38.400 --> 00:21:40.240 to kind of normal absolute humidity

359 00:21:40.240 --> 00:21:42.100 expected for that time of year

360 00:21:42.100 --> 00:21:44.910 and these dips often preceded the onset

361 00:21:44.910 --> 00:21:49.550 of the seasonal influenza epidemic in different US states

362 00:21:49.550 --> 00:21:53.803 by around seven to 14 days,

363 00:21:54.824 --> 00:21:56.380 and this sort of provides good evidence

364 00:21:56.380 --> 00:21:58.940 that there's actually sort of this relationship

365 00:21:58.940 --> 00:22:02.810 where in addition to the experimental evidence,

366 00:22:02.810 --> 00:22:06.200 that absolute humidity is really kind of pre

367 00:22:06.200 --> 00:22:09.603 or precipitating the influence epidemic each year.

368 00:22:12.120 --> 00:22:15.510 And another type of data that's often used

369 00:22:15.510 --> 00:22:18.920 and can potentially be a very strong way

370 00:22:18.920 --> 00:22:22.070 to link infectious disease incidents

371 00:22:22.070 --> 00:22:24.970 to climatic variables is to take advantage

372 00:22:24.970 --> 00:22:28.990 of multi-annual variations in both climate

373 00:22:28.990 --> 00:22:31.710 as well as infectious disease incidents,

374 00:22:31.710 --> 00:22:34.960 and one of the best known multi-annual cycles

375 00:22:34.960 --> 00:22:39.050 when it comes to climate is the El Nino phenomenon

376 00:22:39.050 --> 00:22:41.330 or the El Nino-Southern Oscillation

377 00:22:41.330 --> 00:22:44.044 which has been linked to variation

378 00:22:44.044 --> 00:22:49.044 in cholera cases happening in Bangladesh since the 1990s

379 00:22:51.670 --> 00:22:56.280 through late, or sorry 1980s through late 1990s

380 00:22:56.280 --> 00:22:59.610 where you typically tended to see higher peaks

381 00:22:59.610 --> 00:23:03.620 of cholera epidemics coinciding with years

382 00:23:03.620 --> 00:23:05.420 in which there were

383 00:23:05.420 --> 00:23:09.150 greater sea surface temperature anomalies happening

384 00:23:09.150 --> 00:23:12.110 and these are happening with a frequency

385 00:23:12.110 --> 00:23:14.933 of around five to six years.

386 00:23:17.070 --> 00:23:22.070 However, while these generally provide stronger evidence

387 00:23:22.830 --> 00:23:25.730 in favor of a climate disease link,

388 00:23:25.730 --> 00:23:28.470 since fewer things will vary

389 00:23:28.470 --> 00:23:31.360 at these kind of multi-annual frequencies,

390 00:23:31.360 --> 00:23:33.080 you still need to be careful

391 00:23:33.080 --> 00:23:36.200 when it comes to drawing these causal links

392 00:23:36.200 --> 00:23:40.430 between variations in climate and these variations

393 00:23:40.430 --> 00:23:42.770 in infectious disease incidents,

394 00:23:42.770 --> 00:23:44.490 since infectious diseases can

395 00:23:44.490 --> 00:23:49.270 often exhibit multi-annual cycles that are driven instead

396 00:23:49.270 --> 00:23:51.690 by the internal dynamics of immunity

397 00:23:51.690 --> 00:23:54.470 and susceptibility which I'm gonna touch on

398 00:23:54.470 --> 00:23:56.173 in a couple slides.

399 00:23:58.860 --> 00:24:03.690 And then finally spatial data can often be useful as well.

400 00:24:03.690 --> 00:24:06.450 In particular, the geographic range limits

401 00:24:06.450 --> 00:24:09.870 of a particular pathogen may help to tell you something

402 00:24:09.870 --> 00:24:12.833 about how climate affects its transmission.

403 00:24:13.680 --> 00:24:17.280 For example, this is a distribution map

404 00:24:17.280 --> 00:24:20.050 for the Ixodes scapularis tick

405 00:24:20.050 --> 00:24:22.526 which is the main vector of Lyme disease

406 00:24:22.526 --> 00:24:26.670 within the United States, showing that the

407 00:24:26.670 --> 00:24:30.470 sort of suitable ranges in which we would expect

408 00:24:30.470 --> 00:24:35.270 to see the tick species overlap

409 00:24:35.270 --> 00:24:39.130 with the observed distribution of the tick.

410 00:24:39.130 --> 00:24:42.763 Sorry, I'm accidentally going forward too quickly.

411 00:24:45.967 --> 00:24:50.220 And the one caveat with doing this though is

412 00:24:50.220 --> 00:24:52.630 that you need to be careful not to over interpret

413 00:24:52.630 --> 00:24:54.920 some of the data, since there may also be

414 00:24:54.920 --> 00:24:58.730 other factors involved including behavioral factors

415 00:24:58.730 --> 00:25:00.010 or it just may be possible

416 00:25:00.010 --> 00:25:03.265 that the pathogen hasn't been introduced yet,

417 00:25:03.265 --> 00:25:08.265 for example, to a region where you would predict the climate

418 00:25:08.880 --> 00:25:12.660 to be suitable, but you don't see presence

419 00:25:12.660 --> 00:25:14.543 of the particular pathogen there yet.

420 00:25:16.664 --> 00:25:21.664 And so when it comes to methods for drawing these links

421 00:25:23.970 --> 00:25:28.970 between climate and infectious diseases,

422 00:25:29.410 --> 00:25:32.010 one of the ways that this has traditionally been done

423 00:25:32.010 --> 00:25:37.010 for other diseases not necessarily infectious diseases is

424 00:25:37.140 --> 00:25:40.520 through the use of time series models.

425 00:25:40.520 --> 00:25:43.510 So for example, generalized linear models

426 00:25:43.510 --> 00:25:46.350 such as this Poisson type regression model

427 00:25:46.350 --> 00:25:50.100 which models the log of the number of cases at time t

428 00:25:50.100 --> 00:25:52.250 as a function of the baseline incidence

429 00:25:52.250 --> 00:25:55.070 as well as a variety of different predictors,

430 00:25:55.070 --> 00:25:57.973 some of which may be climatic variables,

431 00:25:59.180 --> 00:26:03.540 but the main limitations of this approach is

432 00:26:03.540 --> 00:26:08.540 that it really assumes that you have independent outcomes

433 00:26:08.600 --> 00:26:11.968 or in other words that the number of cases

434 00:26:11.968 --> 00:26:16.968 of the observed disease at time t is independent

435 00:26:17.200 --> 00:26:20.390 of the number of observed cases of disease

436 00:26:20.390 --> 00:26:23.880 at time t minus one and we know for infectious diseases

437 00:26:23.880 --> 00:26:25.770 that that's just not true

438 00:26:25.770 --> 00:26:28.010 because of the transmission process

439 00:26:28.010 --> 00:26:31.820 and because often the cases at time t minus one

440 00:26:31.820 --> 00:26:36.353 are actually causing the cases happening at time t.

441 00:26:39.190 --> 00:26:41.850 And so models that do not account

442 00:26:41.850 --> 00:26:45.050 for these underlying variations in susceptibility

443 00:26:45.050 --> 00:26:48.370 of the population may fail to identify

444 00:26:48.370 --> 00:26:51.370 some important climate disease relationships.

445 00:26:51.370 --> 00:26:54.810 And this is just an example plotted here

446 00:26:54.810 --> 00:26:57.900 in which we model the potential relationship

447 00:26:57.900 --> 00:27:00.550 between a climactic variable,

448 00:27:00.550 --> 00:27:04.190 in this case we're gonna say precipitation

449 00:27:04.190 --> 00:27:05.900 and we're gonna say that there's this link

450 00:27:05.900 --> 00:27:08.100 between precipitation and climate

451 00:27:08.100 --> 00:27:09.140 which we're modeling

452 00:27:10.260 --> 00:27:13.160 or rather the transmission rate, beta t,

453 00:27:13.160 --> 00:27:15.700 which we're modeling up on the top here

454 00:27:15.700 --> 00:27:20.700 where there is this biannual pattern of precipitation

455 00:27:22.250 --> 00:27:25.840 with two lengths a year causing these sort of two peaks

456 00:27:26.810 --> 00:27:29.005 in the transmission rate happening

457 00:27:29.005 --> 00:27:31.420 at different times of the year.

458 00:27:31.420 --> 00:27:34.480 So this large peak and then this minor peak

459 00:27:34.480 --> 00:27:37.453 in the transmission rate happening each year.

460 00:27:38.360 --> 00:27:41.470 And if you model the incidence of a disease

461 00:27:41.470 --> 00:27:44.231 in which you have a low r-0

462 00:27:44.231 --> 00:27:48.170 or a lower transmission rate within the population,

463 00:27:48.170 --> 00:27:52.370 you see kind of a similar predicted pattern

464 00:27:52.370 --> 00:27:55.550 of cases happening through time

465 00:27:55.550 --> 00:27:58.010 where you see a peak in cases happening

466 00:27:58.010 --> 00:28:00.740 following the peak in precipitation

467 00:28:00.740 --> 00:28:02.653 or the peak in the transmission rates,

468 00:28:03.840 --> 00:28:05.060 followed by a decrease

469 00:28:05.060 --> 00:28:07.560 and then a smaller peak happening coincident

470 00:28:07.560 --> 00:28:10.130 with the smaller peak in the transmission rate

471 00:28:10.130 --> 00:28:12.210 and this pattern kind of repeating over time

472 00:28:12.210 --> 00:28:15.050 where you just see this sort of lag between,

473 00:28:15.050 --> 00:28:17.000 for example your climatic variable

474 00:28:17.000 --> 00:28:18.500 which is shaping transmission here

475 00:28:18.500 --> 00:28:20.563 and your peak in incidence.

476 00:28:21.670 --> 00:28:24.930 But if you take the same model and simulate it

477 00:28:24.930 --> 00:28:29.930 with a higher r-0 or a higher baseline transmission rate,

478 00:28:30.090 --> 00:28:32.370 you can get into these patterns

479 00:28:32.370 --> 00:28:35.010 in which you see a very large epidemic happening,

480 00:28:35.010 --> 00:28:39.340 kind of the first time climate is

481 00:28:39.340 --> 00:28:41.710 sort of favorable to transmission,

482 00:28:41.710 --> 00:28:44.620 but then you've kind of overshot the susceptible population

483 00:28:44.620 --> 00:28:47.460 such that you don't have enough susceptible people around

484 00:28:47.460 --> 00:28:52.000 to cause an epidemic the next time climate is favorable

485 00:28:52.000 --> 00:28:53.560 to transmission happening

486 00:28:53.560 --> 00:28:55.160 and so there's no epidemic happening

487 00:28:55.160 --> 00:28:58.280 even though conditions are favorable this year

488 00:28:59.360 --> 00:29:01.880 and that you have to wait another year

489 00:29:01.880 --> 00:29:04.330 until climate conditions are both favorable

490 00:29:04.330 --> 00:29:07.430 as well as there's enough susceptible individuals around

491 00:29:07.430 --> 00:29:09.470 to have another epidemic occurring.

492 00:29:09.470 --> 00:29:11.210 And you can see that in this instance it would be

493 00:29:11.210 --> 00:29:14.080 very much more difficult to link your climate driver

494 00:29:14.080 --> 00:29:17.197 on top here to the observed incidence of cases happening

495 00:29:17.197 --> 00:29:21.973 in the population as modeled here.

496 00:29:23.310 --> 00:29:28.310 And so as a result, there's a variety of different methods

497 00:29:28.820 --> 00:29:31.200 that can be used and are often used

498 00:29:32.064 --> 00:29:32.897 when specifically looking

499 00:29:32.897 --> 00:29:36.820 at the climate disease relationship for infectious diseases.

500 00:29:36.820 --> 00:29:39.620 and these vary from the traditional statistical methods

501 00:29:39.620 --> 00:29:40.870 that I mentioned earlier

502 00:29:40.870 --> 00:29:43.740 including your generalized linear models

503 00:29:43.740 --> 00:29:47.590 through to models that do account for autocorrelation

504 00:29:47.590 --> 00:29:49.770 within data such as ARIMA models

505 00:29:49.770 --> 00:29:51.770 and time-varying coefficient models

506 00:29:52.920 --> 00:29:57.583 to methods such as time series decomposition and wavelets,

507 00:29:57.583 --> 00:30:02.330 semi-mechanistic models known as TSIR-type models,

508 00:30:02.330 --> 00:30:05.930 down through the fully transdynamic models

509 00:30:05.930 --> 00:30:07.880 such as transmission dynamic models

510 00:30:07.880 --> 00:30:10.150 or individual based models.

511 00:30:10.150 --> 00:30:12.110 And similarly, there are spatial methods

512 00:30:12.110 --> 00:30:15.460 that can be applied as well varying from static risk maps

513 00:30:15.460 --> 00:30:17.860 through to dynamic risk maps

514 00:30:17.860 --> 00:30:18.790 and I'm just gonna touch on

515 00:30:18.790 --> 00:30:20.360 a few of these different examples,

516 00:30:20.360 --> 00:30:22.960 kind of using some of our own work to illustrate it.

517 00:30:23.960 --> 00:30:25.530 So for example, one of the things

518 00:30:25.530 --> 00:30:27.590 that we're working on currently is to try

519 00:30:27.590 --> 00:30:32.110 and understand links between climate and diarrhea incidents

520 00:30:32.110 --> 00:30:35.430 across different districts within Ghana

521 00:30:35.430 --> 00:30:40.430 as modeled or as shown in this map here on the right

522 00:30:42.690 --> 00:30:47.250 where we have the observed incidents per 10,000 individuals

523 00:30:47.250 --> 00:30:50.950 on the left and the model predicted incidents on right

524 00:30:50.950 --> 00:30:52.010 where we're using

525 00:30:52.010 --> 00:30:55.850 a simple time series Poisson regression model

526 00:30:55.850 --> 00:30:58.430 where the log number of cases at time t is a function

527 00:30:58.430 --> 00:31:02.100 of the baseline incidence plus a function

528 00:31:02.100 --> 00:31:06.810 of the mean temperature in the given district at time t,

529 00:31:06.810 --> 00:31:09.220 the diurnal temperature variation,

530 00:31:09.220 --> 00:31:13.000 a model for wetness prevalence

531 00:31:13.000 --> 00:31:14.780 or the presence of wetness

532 00:31:14.780 --> 00:31:17.460 which incorporates precipitation data

533 00:31:17.460 --> 00:31:21.150 as well as often using harmonic terms

534 00:31:21.150 --> 00:31:25.270 for annual and possibly biannual variations in incidents

535 00:31:25.270 --> 00:31:28.310 where you can see the model provides a reasonably good fit

536 00:31:28.310 --> 00:31:33.310 to diarrhea incidents in Navrongo which is a city,

537 00:31:36.010 --> 00:31:38.783 a small city in the northern part of Ghana

538 00:31:38.783 --> 00:31:41.790 as well as Accra which is the main capital

539 00:31:41.790 --> 00:31:44.020 in the southern part of Ghana,

540 00:31:44.020 --> 00:31:46.320 but one of the interesting things when you look

541 00:31:46.320 --> 00:31:49.330 at actual correlations and the coefficients

542 00:31:49.330 --> 00:31:53.520 within these models is that you see opposite relationships

543 00:31:53.520 --> 00:31:56.630 between your climatic variables

544 00:31:56.630 --> 00:32:01.630 including the mean temperature in this panel,

545 00:32:02.240 --> 00:32:04.850 the second panel as well as the wetness prevalence

546 00:32:04.850 --> 00:32:09.450 or a measure of precipitation in the fourth panel here

547 00:32:09.450 --> 00:32:11.330 in the northern part of the country

548 00:32:11.330 --> 00:32:13.480 versus the southern part of the country,

549 00:32:13.480 --> 00:32:14.660 where here we're plotting

550 00:32:14.660 --> 00:32:17.420 the Pearson correlation coefficient

551 00:32:17.420 --> 00:32:19.430 across these different areas and showing

552 00:32:19.430 --> 00:32:23.080 that you see negative associations between temperature

553 00:32:23.080 --> 00:32:25.000 and diarrhea incidence in the north

554 00:32:25.000 --> 00:32:27.500 and positive associations in the south

555 00:32:27.500 --> 00:32:29.150 whereas you see the opposite pattern

556 00:32:29.150 --> 00:32:31.930 when it comes to wetness presence

557 00:32:31.930 --> 00:32:34.500 where it tends to be positive associations in the north

558 00:32:34.500 --> 00:32:38.520 and more negative associations found in the south.

559 00:32:38.520 --> 00:32:40.740 And so it's I think gonna be difficult

560 00:32:40.740 --> 00:32:44.400 to really kind of tease apart what are the main drivers

561 00:32:44.400 --> 00:32:46.490 of these differences and what are the other factors

562 00:32:46.490 --> 00:32:48.810 that are involved that really explain

563 00:32:48.810 --> 00:32:51.485 sort of the differences in climate,

564 00:32:51.485 --> 00:32:56.430 in the role that climatic factors play in diarrhea

565 00:32:56.430 --> 00:32:59.417 in this setting, and one of the ways that we can do this

566 00:32:59.417 --> 00:33:01.180 and that we're planning to do this

567 00:33:02.070 --> 00:33:06.550 is using spatiotemporal models and this is a previous study

568 00:33:07.930 --> 00:33:11.970 in which we use spatiotemporal hierarchical Bayesian models

569 00:33:11.970 --> 00:33:15.217 to look at diarrhea and the associations between climate

570 00:33:15.217 --> 00:33:18.350 and diarrhea incidents in Afghanistan

571 00:33:18.350 --> 00:33:21.450 and using these methods, we're really kind of able

572 00:33:21.450 --> 00:33:26.450 to show that higher diarrhea incidents

573 00:33:27.180 --> 00:33:28.930 which tended to be concentrated

574 00:33:28.930 --> 00:33:33.410 around the population centers in the northeast

575 00:33:33.410 --> 00:33:36.270 as well as in some of the other

576 00:33:36.270 --> 00:33:39.780 kind of northern outlying regions is really associated

577 00:33:39.780 --> 00:33:44.780 with both positively with aridity and fluctuations

578 00:33:46.150 --> 00:33:49.400 in mean daily temperature as well as negatively

579 00:33:49.400 --> 00:33:53.450 with changes in average annual temperature

580 00:33:53.450 --> 00:33:58.000 where colder parts of the country tended

581 00:33:58.000 --> 00:34:01.840 to have a higher incidence than might be expected

582 00:34:01.840 --> 00:34:03.113 kind of otherwise.

583 00:34:07.669 --> 00:34:10.467 And another way in which we can use different

584 00:34:11.960 --> 00:34:15.900 or another approach rather to using models

585 00:34:15.900 --> 00:34:19.250 to tease apart these climate disease relationships is

586 00:34:19.250 --> 00:34:22.730 to use what's called a TSIR type model

587 00:34:22.730 --> 00:34:25.580 which is a semi-mechanistic model

588 00:34:26.780 --> 00:34:29.763 which estimates the susceptible population

589 00:34:29.763 --> 00:34:32.760 through time at each time point

590 00:34:32.760 --> 00:34:36.485 as well as the affected population at each time

591 00:34:36.485 --> 00:34:40.810 and incorporates it into a regression type of framework

592 00:34:40.810 --> 00:34:44.650 such as this where we can kind of model out

593 00:34:44.650 --> 00:34:47.390 the transmission rate through time

594 00:34:47.390 --> 00:34:51.260 and make it a function of different climatic variables

595 00:34:51.260 --> 00:34:53.530 and this is an approach that we used along

596 00:34:53.530 --> 00:34:56.380 with colleagues from Princeton to examine the relationships

597 00:34:56.380 --> 00:35:00.100 between humidity, rainfall and cases

598 00:35:00.100 --> 00:35:03.610 of Respiratory syncytial virus or RSV

599 00:35:03.610 --> 00:35:07.370 across different parts of the US and Mexico

600 00:35:07.370 --> 00:35:11.330 under both current and future climates.

601 00:35:11.330 --> 00:35:14.110 And using this approach, we were able to show

602 00:35:14.110 --> 00:35:18.153 that the transmission rates of RSV

603 00:35:19.547 --> 00:35:23.460 which is indicated by the various colors here,

604 00:35:23.460 --> 00:35:28.160 tended to depend both on the level of humidity

605 00:35:28.160 --> 00:35:30.180 within the population where it tended

606 00:35:30.180 --> 00:35:32.770 to be higher transmission happening

607 00:35:32.770 --> 00:35:35.640 at lower specific humidity as well as

608 00:35:35.640 --> 00:35:39.010 on the level of precipitation within the population

609 00:35:39.010 --> 00:35:41.400 where particularly at kind of middle

610 00:35:41.400 --> 00:35:43.240 to higher specific humidity,

611 00:35:43.240 --> 00:35:45.470 precipitation played a larger role

612 00:35:45.470 --> 00:35:49.210 in modulating transmission of RSV

613 00:35:50.170 --> 00:35:51.630 and this really helped to explain

614 00:35:51.630 --> 00:35:53.880 some of the very different patterns that we see

615 00:35:53.880 --> 00:35:55.890 in sort of the seasonality of RSV

616 00:35:55.890 --> 00:35:57.880 across different parts of the US

617 00:35:57.880 --> 00:36:00.580 where we see this sort of biennial every other year pattern

618 00:36:00.580 --> 00:36:04.520 of large followed by small epidemics often happening

619 00:36:04.520 --> 00:36:08.220 in Upper Midwestern states such as Minnesota,

620 00:36:08.220 --> 00:36:11.380 kind of regular annual seasonal outbreaks happening

621 00:36:11.380 --> 00:36:12.460 in the winter in states

622 00:36:12.460 --> 00:36:15.500 such as New York and Connecticut, earlier epidemics

623 00:36:15.500 --> 00:36:18.000 with kind of more year-round transmissioning happening

624 00:36:18.000 --> 00:36:19.960 in Florida and these sort of biannual

625 00:36:19.960 --> 00:36:23.670 two peaks a year happening in parts of Mexico.

626 00:36:23.670 --> 00:36:27.100 And by linking this kind of specific relationship

627 00:36:27.100 --> 00:36:31.350 between the transmission rates to these climatic factors,

628 00:36:31.350 --> 00:36:33.160 we're able to make projections

629 00:36:33.160 --> 00:36:36.938 about the impacts of climate on future disease incidents

630 00:36:36.938 --> 00:36:41.400 which is shown on the plots over here

631 00:36:41.400 --> 00:36:45.120 on the map on the right in which we predict

632 00:36:45.120 --> 00:36:50.120 that overall transmission rates of RSV will be lower

633 00:36:51.510 --> 00:36:54.210 in the future in the Upper Midwest

634 00:36:54.210 --> 00:36:56.130 and Northeastern United States,

635 00:36:56.130 --> 00:36:58.440 but potentially higher seasonal differences

636 00:36:58.440 --> 00:37:01.870 in transmission in the west as well as the south,

637 00:37:01.870 --> 00:37:03.340 although there's a lot of uncertainty

638 00:37:03.340 --> 00:37:05.350 in some of these model predictions,

639 00:37:05.350 --> 00:37:07.810 partly related to uncertainty

640 00:37:07.810 --> 00:37:10.133 in rainfall predictions going forward.

641 00:37:11.170 --> 00:37:13.480 And we've also used this approach to look

642 00:37:13.480 --> 00:37:17.701 at the relationship between rainfall

643 00:37:17.701 --> 00:37:22.650 and typhoid fever using historical data from the US

644 00:37:22.650 --> 00:37:25.040 where we had data from 19 cities

645 00:37:25.040 --> 00:37:27.370 across different parts of the US

646 00:37:27.370 --> 00:37:29.920 and found this really kind of interesting differences

647 00:37:29.920 --> 00:37:31.710 in seasonal patterns between cities where

648 00:37:31.710 --> 00:37:33.550 for example in New York,

649 00:37:33.550 --> 00:37:36.980 we saw very strongly seasonal epidemics peaking

650 00:37:36.980 --> 00:37:39.290 of typhoid fever before,

651 00:37:39.290 --> 00:37:43.600 this is data from like the late 1880s, early 1900s

652 00:37:43.600 --> 00:37:46.660 where you saw these typhoid fever epidemics peaking

653 00:37:46.660 --> 00:37:49.540 every summer, early fall

654 00:37:49.540 --> 00:37:51.890 whereas in a city like Philadelphia

655 00:37:51.890 --> 00:37:54.340 which was right next door,

656 00:37:54.340 --> 00:37:57.258 there's very little kind of seasonal variation in climate

657 00:37:57.258 --> 00:37:59.330 and one of the things that we were able

658 00:37:59.330 --> 00:38:03.660 to identify oh sorry, seasonal variation

659 00:38:03.660 --> 00:38:04.970 in the typhoid transmission rate,

660 00:38:04.970 --> 00:38:07.080 and by teasing apart these variations

661 00:38:07.080 --> 00:38:07.950 in the transmission rate,

662 00:38:07.950 --> 00:38:12.323 one of the things that we identified was that the amount

663 00:38:13.210 --> 00:38:15.410 of seasonal variation in the transmission rate

664 00:38:15.410 --> 00:38:19.380 really tended to vary depending on the primary water source

665 00:38:19.380 --> 00:38:24.380 for the city where cities that relied on reservoirs,

666 00:38:24.640 --> 00:38:28.000 often reservoirs that were outside of the city

667 00:38:28.000 --> 00:38:31.380 such as the New York reservoir which is located

668 00:38:31.380 --> 00:38:34.180 in upstate, upstate New York

669 00:38:34.180 --> 00:38:38.070 as well as outside of Boston and in Baltimore,

670 00:38:38.070 --> 00:38:40.610 tended to exhibit these kind of stronger

671 00:38:40.610 --> 00:38:43.900 overall seasonal variations summarized in the plot

672 00:38:43.900 --> 00:38:45.970 on the bottom right here,

673 00:38:45.970 --> 00:38:49.420 compared to cities that relied on data

674 00:38:49.420 --> 00:38:53.530 or a water from nearby rivers or rivers that ran

675 00:38:53.530 --> 00:38:56.630 through the city such as in Philadelphia

676 00:38:56.630 --> 00:38:59.520 or cities that drove their water from the great lakes

677 00:38:59.520 --> 00:39:01.770 which actually had the lowest seasonal variation

678 00:39:01.770 --> 00:39:04.620 in transmission rates and so taking into part,

679 00:39:04.620 --> 00:39:06.690 into account kind of other factors

680 00:39:06.690 --> 00:39:08.880 such as water sources is really important

681 00:39:08.880 --> 00:39:11.760 in understanding some of these relationships.

682 00:39:11.760 --> 00:39:14.490 And overall, this relationship between

683 00:39:14.490 --> 00:39:17.260 kind of temperature and you know,

684 00:39:17.260 --> 00:39:19.140 why transmission rates tend to peak

685 00:39:19.140 --> 00:39:22.710 in the summer months was consistent with results

686 00:39:22.710 --> 00:39:24.780 of a systematic review that we conducted

687 00:39:24.780 --> 00:39:27.310 looking at associations between climate

688 00:39:27.310 --> 00:39:30.380 and typhoid fever incidents that generally showed

689 00:39:30.380 --> 00:39:34.900 that temperature on the bottom here was a stronger correlate

690 00:39:34.900 --> 00:39:37.963 of typhoid fever incidence at lags of zero

691 00:39:37.963 --> 00:39:41.190 to two months across different latitudes

692 00:39:41.190 --> 00:39:44.250 and studies conducted across different latitudes

693 00:39:44.250 --> 00:39:45.790 compared to rainfall which is really

694 00:39:45.790 --> 00:39:49.000 kind of only associated often in studies conducted

695 00:39:49.000 --> 00:39:51.530 in the monsoon belts where,

696 00:39:51.530 --> 00:39:55.290 and you often also saw potentially negative associations

697 00:39:55.290 --> 00:39:58.078 between rainfall and typhoid fever incidents

698 00:39:58.078 --> 00:40:00.623 in places such as the Middle East.

699 00:40:02.290 --> 00:40:04.680 And then finally, one of the last ways

700 00:40:04.680 --> 00:40:09.474 in which we can estimate the climate disease relationship is

701 00:40:09.474 --> 00:40:12.380 to incorporate climate models

702 00:40:12.380 --> 00:40:16.660 into fully mechanistic dynamic models

703 00:40:16.660 --> 00:40:20.710 which explicitly account for the susceptible, infected

704 00:40:20.710 --> 00:40:23.363 and recovered populations through time.

705 00:40:24.502 --> 00:40:26.370 And so for example the way this works is

706 00:40:26.370 --> 00:40:29.320 to assume in your population

707 00:40:29.320 --> 00:40:32.760 that all individuals are born susceptible

708 00:40:32.760 --> 00:40:37.410 to a particular disease and that they become infected

709 00:40:37.410 --> 00:40:40.340 at a rate which we're gonna call lambda

710 00:40:40.340 --> 00:40:44.507 and remain infectious for a period of time

711 00:40:45.840 --> 00:40:48.915 after which they recover and have some immunity

712 00:40:48.915 --> 00:40:52.020 to future infections of the disease

713 00:40:52.020 --> 00:40:54.360 and the important part about these models is

714 00:40:54.360 --> 00:40:56.950 that this lambda parameter or the rate

715 00:40:56.950 --> 00:41:00.181 from going to susceptible to infected depends

716 00:41:00.181 --> 00:41:04.820 on the current prevalence of infectious individuals

717 00:41:04.820 --> 00:41:07.790 within your population through time,

718 00:41:07.790 --> 00:41:11.090 such that the lambda at time t is gonna be a function

719 00:41:11.090 --> 00:41:13.450 of our transmission rate at time t,

720 00:41:13.450 --> 00:41:16.040 times the number of currently susceptible individuals

721 00:41:16.040 --> 00:41:19.020 and times the number of currently infectious individuals

722 00:41:19.020 --> 00:41:20.880 within our population.

723 00:41:20.880 --> 00:41:23.920 And so our incidence of new cases is dependent

724 00:41:23.920 --> 00:41:28.920 not just on the transmission rate or climatic variables

725 00:41:29.260 --> 00:41:30.660 which may affect the transmission rate,

726 00:41:30.660 --> 00:41:32.390 but also on the current prevalence

727 00:41:32.390 --> 00:41:34.340 of the infection within the population.

728 00:41:35.320 --> 00:41:36.610 And then within these models,

729 00:41:36.610 --> 00:41:39.160 we can decompose this transmission rate

730 00:41:39.160 --> 00:41:41.790 or this beta parameter at time t

731 00:41:41.790 --> 00:41:45.680 to be a function of various other factors

732 00:41:45.680 --> 00:41:48.840 and often the way we model it is as a function

733 00:41:48.840 --> 00:41:50.824 of sort of a baseline transmission rate

734 00:41:50.824 --> 00:41:53.590 plus some seasonal variation

735 00:41:53.590 --> 00:41:56.910 which we may not understand kind of all the factors leading

736 00:41:56.910 --> 00:42:00.240 into the seasonal variation, but using a harmonic term

737 00:42:00.240 --> 00:42:03.350 and then can incorporate our various climatic predictors

738 00:42:03.350 --> 00:42:08.293 as coefficients in this equation for our beta t parameter.

739 00:42:09.490 --> 00:42:13.110 And this is something that we've done to look at the impacts

740 00:42:13.110 --> 00:42:18.110 of climate on rotavirus diarrhea in particular in Bangladesh

741 00:42:18.550 --> 00:42:21.430 where we're using this slightly more complicated model

742 00:42:21.430 --> 00:42:25.150 specific to our understanding of immunity

743 00:42:25.150 --> 00:42:27.880 and natural history of rotavirus infections

744 00:42:27.880 --> 00:42:30.370 which is depicted on the left here

745 00:42:30.370 --> 00:42:32.980 and modeling our incidence rate at time t

746 00:42:32.980 --> 00:42:36.380 as a function, not only of sort of the baseline incidence

747 00:42:36.380 --> 00:42:38.500 and these harmonic terms accounting for

748 00:42:38.500 --> 00:42:42.500 kind of annual and bi-annual potential differences

749 00:42:42.500 --> 00:42:44.470 or changes in transmission rate,

750 00:42:44.470 --> 00:42:45.930 but also climatic terms

751 00:42:45.930 --> 00:42:49.410 including the diurnal temperature variation

752 00:42:49.410 --> 00:42:52.840 which is plotted in the middle here

753 00:42:52.840 --> 00:42:56.940 showing kind of a larger diurnal temperature variation

754 00:42:56.940 --> 00:43:00.520 happening in the kind of winter months

755 00:43:00.520 --> 00:43:02.210 or early parts of the year

756 00:43:02.210 --> 00:43:05.010 and less diurnal temperature variation

757 00:43:05.010 --> 00:43:06.363 in the middle of the year,

758 00:43:08.110 --> 00:43:11.160 as well as the wetness presence

759 00:43:11.160 --> 00:43:15.010 which tends to be more higher

760 00:43:15.010 --> 00:43:17.010 in the middle parts of the year

761 00:43:17.010 --> 00:43:19.170 coinciding with the monsoon season

762 00:43:19.170 --> 00:43:21.580 and you can see the rotavirus incidence

763 00:43:21.580 --> 00:43:24.540 in this particular setting, if you kind of average it

764 00:43:24.540 --> 00:43:27.080 over time shows these sort of bi-annual peaks

765 00:43:27.080 --> 00:43:28.670 where you have a larger peak happening

766 00:43:28.670 --> 00:43:31.330 kind of in the cooler, dry season

767 00:43:31.330 --> 00:43:33.580 and then a smaller secondary peak happening

768 00:43:33.580 --> 00:43:35.690 in the wet season over time

769 00:43:35.690 --> 00:43:37.580 and we can use kind of this relationship

770 00:43:37.580 --> 00:43:41.340 to try and tease apart some of those relationships

771 00:43:41.340 --> 00:43:45.410 and how they're associated with climate factors

772 00:43:45.410 --> 00:43:48.390 as well as other factors within the population

773 00:43:48.390 --> 00:43:52.210 and you can see that we have plotted here

774 00:43:52.210 --> 00:43:55.450 the incidence of rotavirus diarrhea from the 1990s

775 00:43:55.450 --> 00:43:57.830 to early 2000s as well as incidents

776 00:43:57.830 --> 00:44:02.510 over kind of a later time period from 2003 to 2013

777 00:44:02.510 --> 00:44:05.850 where if we fit models to the early time period

778 00:44:05.850 --> 00:44:08.600 and use it to predict the later time period

779 00:44:08.600 --> 00:44:11.900 which is shown in blue here,

780 00:44:11.900 --> 00:44:15.070 we can generally kind of capture some of these patterns

781 00:44:15.070 --> 00:44:18.700 in which we observe a stronger kind of bi-annual pattern

782 00:44:18.700 --> 00:44:22.320 or two peaks a year happening across the 1990s

783 00:44:22.320 --> 00:44:26.340 and early 2000s, but a much more kind of annual pattern

784 00:44:26.340 --> 00:44:29.473 that emerges in the later 2000s,

785 00:44:31.417 --> 00:44:35.090 in 2000 through 2013 where you're starting to see

786 00:44:35.090 --> 00:44:38.570 much greater predominance of this annual

787 00:44:38.570 --> 00:44:42.440 kind of winter dry season peak and it doesn't seem

788 00:44:42.440 --> 00:44:44.390 that this is necessarily related to variation

789 00:44:44.390 --> 00:44:47.620 in climate over time, but really is more driven

790 00:44:47.620 --> 00:44:50.150 by actually a decline in the birth rate

791 00:44:50.150 --> 00:44:54.438 within Bangladesh and particularly within Dhaka

792 00:44:54.438 --> 00:44:57.360 which is sort of interacting

793 00:44:57.360 --> 00:44:59.760 with the different climatic factors

794 00:44:59.760 --> 00:45:03.043 to change the sort of the predominant way

795 00:45:04.790 --> 00:45:08.370 in which the climate influences transmission of rotavirus

796 00:45:08.370 --> 00:45:11.360 within the setting, where kind of even modeling

797 00:45:11.360 --> 00:45:14.160 kind of same relationships between climate

798 00:45:14.160 --> 00:45:16.660 and rotavirus transmission over time,

799 00:45:16.660 --> 00:45:21.660 we can capture this shift from kind of more biannual peaks

800 00:45:22.200 --> 00:45:27.200 to greater predominance of annual peaks over time

801 00:45:30.720 --> 00:45:33.070 and so finally, I just wanna talk a little bit

802 00:45:33.070 --> 00:45:36.617 about how we can kind of pull everything together

803 00:45:36.617 --> 00:45:40.340 and how we can make these predictions

804 00:45:40.340 --> 00:45:44.260 around the impacts of climate change on infectious diseases.

805 00:45:44.260 --> 00:45:46.450 And again, the way that we do this is

806 00:45:46.450 --> 00:45:49.020 to really combine our climate model projections

807 00:45:49.020 --> 00:45:51.240 with a good understanding

808 00:45:51.240 --> 00:45:55.003 of the incidence of disease given climate,

809 00:45:55.872 --> 00:45:59.040 but then there's still a number of big challenges

810 00:45:59.040 --> 00:45:59.873 in doing this.

811 00:45:59.873 --> 00:46:02.890 Often the climate models have poor resolution

812 00:46:02.890 --> 00:46:06.033 and wide uncertainty which needs to be propagated

813 00:46:06.033 --> 00:46:11.033 throughout the relationships of predictions going forward

814 00:46:12.520 --> 00:46:15.460 and infectious diseases may often vary

815 00:46:15.460 --> 00:46:17.830 based not only on mean climate,

816 00:46:17.830 --> 00:46:19.930 but can also show important variability

817 00:46:19.930 --> 00:46:23.630 on shorter spatial and temporal scales

818 00:46:23.630 --> 00:46:26.420 such that things like diurnal temperature variation

819 00:46:26.420 --> 00:46:29.250 or changes in climate kind of through the day

820 00:46:29.250 --> 00:46:31.740 can have important impacts often on climate

821 00:46:31.740 --> 00:46:33.720 or on infectious disease transmission

822 00:46:35.080 --> 00:46:39.480 and then finally, the associations with climate are often,

823 00:46:39.480 --> 00:46:43.150 I would say non-linear, when it comes to infectious diseases

824 00:46:44.110 --> 00:46:47.250 and climate models are often bad at predicting

825 00:46:47.250 --> 00:46:49.900 some of the extremes and extremes in temperature

826 00:46:49.900 --> 00:46:54.050 and rainfall for example which have been shown

827 00:46:54.050 --> 00:46:55.920 to be kind of important drivers

828 00:46:56.780 --> 00:46:59.680 of a transmission of infectious diseases

829 00:47:00.990 --> 00:47:03.070 and then finally, another important caveat is

830 00:47:03.070 --> 00:47:06.110 that the impacts of climate change may be quite small

831 00:47:06.110 --> 00:47:09.030 relative to the impacts of human interventions

832 00:47:09.030 --> 00:47:11.260 and demographic changes as we saw

833 00:47:11.260 --> 00:47:13.040 with the rotavirus example,

834 00:47:13.040 --> 00:47:17.350 but as we also see with models of projections

835 00:47:17.350 --> 00:47:19.810 around malaria risk over time

836 00:47:19.810 --> 00:47:21.760 where if you were to just simply look back

837 00:47:21.760 --> 00:47:25.519 at the malaria risk map from the 1900s

838 00:47:25.519 --> 00:47:30.370 and compare it to the malaria risk map from 2007,

839 00:47:30.370 --> 00:47:33.670 you'll see that the overall regions

840 00:47:33.670 --> 00:47:37.590 in which you see malaria has contracted significantly

841 00:47:37.590 --> 00:47:39.960 where we no longer see malaria happening

842 00:47:39.960 --> 00:47:42.350 in parts of the US for example,

843 00:47:42.350 --> 00:47:45.770 but really being more confined to parts of Africa

844 00:47:45.770 --> 00:47:48.582 and Asia and other places.

845 00:47:48.582 --> 00:47:53.582 But at the same time, the climate has actually been warming

846 00:47:54.640 --> 00:47:57.780 and this would suggest that you would see

847 00:47:57.780 --> 00:48:00.130 more favorable conditions for malaria climate

848 00:48:00.130 --> 00:48:04.540 if you'd only take into account climate over time

849 00:48:04.540 --> 00:48:07.140 and so while what's actually been observed is

850 00:48:07.140 --> 00:48:09.510 mostly been driven by human interventions

851 00:48:09.510 --> 00:48:13.390 and changes in development and exposure to mosquitoes.

852 00:48:13.390 --> 00:48:15.238 If you don't take into account those changes,

853 00:48:15.238 --> 00:48:17.490 you would totally misunderstand

854 00:48:18.536 --> 00:48:20.260 or misrepresent the climate associations

855 00:48:20.260 --> 00:48:21.913 that we know are there.

856 00:48:23.410 --> 00:48:25.140 And so in terms of the way forward,

857 00:48:25.140 --> 00:48:29.270 what really needs to be done is to take on

858 00:48:29.270 --> 00:48:31.330 some of these climate disease relationships

859 00:48:31.330 --> 00:48:34.900 in which we have experimental systems set up

860 00:48:34.900 --> 00:48:38.050 and we have a better understanding of the relationship

861 00:48:38.050 --> 00:48:41.860 between climate and how it impacts on infectious diseases.

862 00:48:41.860 --> 00:48:43.900 Furthermore, some of the climate change productions are

863 00:48:43.900 --> 00:48:47.010 gonna be more reliable and so those infectious diseases

864 00:48:47.010 --> 00:48:50.250 that rely on or have been shown to vary

865 00:48:50.250 --> 00:48:53.080 based on climate variables which are more predictable,

866 00:48:53.080 --> 00:48:54.990 I think, are gonna be kind of more amenable

867 00:48:54.990 --> 00:48:59.990 to making predictions around the impacts of climate change.

868 00:49:00.730 --> 00:49:04.160 But overall, there's really I think an important need

869 00:49:04.160 --> 00:49:07.228 for interdisciplinary work between climate scientists,

870 00:49:07.228 --> 00:49:11.580 lab scientists and microbiologists who can help

871 00:49:11.580 --> 00:49:13.718 to test some of these mechanisms

872 00:49:13.718 --> 00:49:15.770 and infectious disease modelers

873 00:49:15.770 --> 00:49:18.140 who can quantify the relationships

874 00:49:18.140 --> 00:49:22.670 between climate and infectious diseases to really,

875 00:49:22.670 --> 00:49:25.240 I think, move forward some of the field

876 00:49:27.280 --> 00:49:29.916 when it comes to trying to make impacts

877 00:49:29.916 --> 00:49:32.950 or predictions around impacts of climate change

878 00:49:32.950 --> 00:49:34.540 on infectious diseases,

879 00:49:34.540 --> 00:49:38.570 and in doing so we really need to take into account factors

880 00:49:38.570 --> 00:49:41.160 such as human adaptation and the impacts

881 00:49:41.160 --> 00:49:43.520 that climate may have on human behavior

882 00:49:43.520 --> 00:49:45.870 and population distribution

883 00:49:45.870 --> 00:49:49.570 since these are often kind of greater drivers

884 00:49:49.570 --> 00:49:51.630 of infectious disease incidents

885 00:49:51.630 --> 00:49:56.630 than factors affecting pathogen survival for example.

886 00:49:57.110 --> 00:49:59.340 And so really there's this need to move beyond

887 00:49:59.340 --> 00:50:02.690 just the simple climate disease correlations

888 00:50:02.690 --> 00:50:05.780 that other I think previous attempts

889 00:50:05.780 --> 00:50:09.563 to predict the impacts of climate change have relied upon.

890 00:50:10.730 --> 00:50:14.630 And so finally I just want to quickly acknowledge

891 00:50:14.630 --> 00:50:16.130 some of the people who I've worked with

892 00:50:16.130 --> 00:50:19.530 on these various projects including collaborators

893 00:50:19.530 --> 00:50:22.610 and lab members here at Yale

894 00:50:22.610 --> 00:50:24.380 as well as collaborators elsewhere

895 00:50:24.380 --> 00:50:26.750 and funding from the

896 00:50:26.750 --> 00:50:28.270 Yale Climate Change and Health Initiative

897 00:50:28.270 --> 00:50:30.360 as well as NIH, the Gates Foundation

898 00:50:30.360 --> 00:50:32.560 and collaborators funding from Welcome Trust

899 00:50:32.560 --> 00:50:34.480 and James McDonald.

900 00:50:34.480 --> 00:50:37.123 So I'd be happy to take any questions.

901 00:50:40.800 --> 00:50:42.350 - Thank you.

902 00:50:42.350 --> 00:50:44.620 Very wonderful presentation.

903 00:50:44.620 --> 00:50:47.110 I think it covers all the aspects

904 00:50:47.110 --> 00:50:50.050 when we talk about conscientious infectious disease

905 00:50:50.050 --> 00:50:53.410 from modeling the climate disease relationship

906 00:50:53.410 --> 00:50:57.890 to how to better project the future impacts.

907 00:50:57.890 --> 00:51:01.730 So we do have a lot of questions from the students.

908 00:51:01.730 --> 00:51:04.870 So because we only have very limited time,

909 00:51:04.870 --> 00:51:09.870 so I will summarize two questions from the students

910 00:51:10.050 --> 00:51:11.810 and if we have more time,

911 00:51:11.810 --> 00:51:16.130 then maybe our audience can speak for their questions.

912 00:51:16.130 --> 00:51:17.580 - Great. - The first question is

913 00:51:17.580 --> 00:51:21.460 kind of follow up your later part talking

914 00:51:21.460 --> 00:51:26.020 about the inferences of the non-climatic drivers.

915 00:51:26.020 --> 00:51:30.170 You're showing that actually human intervention

916 00:51:30.170 --> 00:51:33.330 can have much larger impacts.

917 00:51:33.330 --> 00:51:38.330 So students are wondering how do you consider this

918 00:51:38.810 --> 00:51:42.730 in projecting the future climate change impacts?

919 00:51:42.730 --> 00:51:45.130 - Yeah I mean I think that that's often the difficulty

920 00:51:45.130 --> 00:51:47.910 when it comes to making predictions

921 00:51:47.910 --> 00:51:52.480 about the future is understanding how you know,

922 00:51:52.480 --> 00:51:55.050 you can make projections kind of assuming

923 00:51:55.050 --> 00:51:56.610 all other things remain the same

924 00:51:56.610 --> 00:51:58.580 and climate's the only thing that's changing,

925 00:51:58.580 --> 00:52:00.470 but the reality is that climate's never gonna be

926 00:52:00.470 --> 00:52:02.820 the only thing that changes over time

927 00:52:02.820 --> 00:52:06.470 and so you have to have either some other model

928 00:52:06.470 --> 00:52:11.470 for how human behavior may change over time

929 00:52:12.770 --> 00:52:15.780 or human development or things like that may change

930 00:52:15.780 --> 00:52:18.010 over time and that may just be sort of trying

931 00:52:18.010 --> 00:52:21.790 to make simple extrapolations or maybe

932 00:52:21.790 --> 00:52:24.440 based on sort of more sophisticated

933 00:52:25.780 --> 00:52:28.760 kind of sociological or sociopolitical models

934 00:52:28.760 --> 00:52:32.340 of say, development or things that other factors

935 00:52:32.340 --> 00:52:37.340 that may affect like interact the risk of disease.

936 00:52:38.310 --> 00:52:41.100 So for example when it comes to malaria,

937 00:52:41.100 --> 00:52:44.447 obviously sort of some of the developmental factors

938 00:52:44.447 --> 00:52:48.737 and industrialization that happened

939 00:52:48.737 --> 00:52:53.737 that led to kind of clearing of mosquito breeding sites

940 00:52:54.010 --> 00:52:56.020 and things like that played a huge role

941 00:52:56.020 --> 00:52:58.472 in kind of why we no longer see malaria

942 00:52:58.472 --> 00:53:02.971 in parts of the world where it was previously,

943 00:53:02.971 --> 00:53:07.340 but yeah, I mean I think you need a separate model

944 00:53:07.340 --> 00:53:08.980 to really account for

945 00:53:08.980 --> 00:53:11.620 how we see those things changing over time

946 00:53:11.620 --> 00:53:15.143 separate from or potentially related to climate.

947 00:53:17.830 --> 00:53:22.830 - Wonderful, so while Gina is answering questions,

948 00:53:23.713 --> 00:53:25.670 from the audience, if you do have any questions,

949 00:53:25.670 --> 00:53:29.120 you can type your questions in the chat box

950 00:53:29.120 --> 00:53:31.960 or if you are willing to speak,

951 00:53:31.960 --> 00:53:35.580 you can raise your hand

952 00:53:35.580 --> 00:53:37.860 and then we can ask you the questions.

953 00:53:37.860 --> 00:53:42.860 So I have actually a couple questions from the students

954 00:53:42.970 --> 00:53:46.730 given we are under you know the COVID 19 pandemic.

955 00:53:46.730 --> 00:53:48.390 We are very interested in like

956 00:53:49.248 --> 00:53:51.880 what's your answer to the climate inference

957 00:53:51.880 --> 00:53:54.050 on the transmission of COVID 19

958 00:53:55.373 --> 00:53:57.310 and what are the potential challenges

959 00:53:57.310 --> 00:54:02.310 in using the approaches that you are talking about today

960 00:54:02.610 --> 00:54:05.797 to study the relationship between COVID 19

961 00:54:05.797 --> 00:54:07.403 and all the climate drivers.

962 00:54:08.654 --> 00:54:09.680 - Yeah, I mean I think that that's definitely something

963 00:54:09.680 --> 00:54:11.430 that some people have tried

964 00:54:11.430 --> 00:54:14.240 to kind of tease apart using data

965 00:54:14.240 --> 00:54:16.390 I think mostly from kind of different locations

966 00:54:16.390 --> 00:54:18.550 and trying to understand kind of how

967 00:54:19.690 --> 00:54:23.890 perhaps how quickly the epidemic has taken off

968 00:54:23.890 --> 00:54:27.130 in different locations could potentially be explained

969 00:54:27.130 --> 00:54:31.638 by some of the differences in climate possibly

970 00:54:31.638 --> 00:54:35.170 and so I mean I think that that is potentially one approach

971 00:54:35.170 --> 00:54:39.180 to take, but really doesn't factor in

972 00:54:39.180 --> 00:54:43.503 all of the other things that may potentially affect

973 00:54:47.640 --> 00:54:49.930 whether it's climate that's driving

974 00:54:49.930 --> 00:54:52.960 how quickly the epidemic takes off across different places

975 00:54:52.960 --> 00:54:54.520 or whether it's other factors,

976 00:54:54.520 --> 00:54:59.520 for example just kind of the extent of social distancing,

977 00:55:00.060 --> 00:55:01.410 the extent of other interventions

978 00:55:01.410 --> 00:55:04.100 and how all of those things have played a role

979 00:55:04.100 --> 00:55:06.590 or just chance in terms of when the virus was introduced

980 00:55:06.590 --> 00:55:08.380 in different places in determining

981 00:55:08.380 --> 00:55:10.000 kind of how quickly the epidemic has occurred

982 00:55:10.000 --> 00:55:12.193 in different locations.

983 00:55:13.690 --> 00:55:15.250 Another approach that has been taken is

984 00:55:15.250 --> 00:55:20.130 to look at our understanding of other Coronaviruses

985 00:55:20.130 --> 00:55:22.780 within the human population

986 00:55:22.780 --> 00:55:24.710 and there are kind of

987 00:55:26.600 --> 00:55:30.930 at least two other human Coronavirus species

988 00:55:30.930 --> 00:55:35.320 that cause cold like illness every year

989 00:55:35.320 --> 00:55:36.930 that circulate within the US

990 00:55:36.930 --> 00:55:41.060 and we know that those other Coronaviruses

991 00:55:41.060 --> 00:55:45.876 tend to peak in the fall, early winter time period

992 00:55:45.876 --> 00:55:50.660 and likely the reasons behind why they peak in the fall

993 00:55:50.660 --> 00:55:52.640 and winter time period is really related

994 00:55:52.640 --> 00:55:56.810 to climate conditions favoring transmission,

995 00:55:56.810 --> 00:55:59.420 be it from what I talked about earlier

996 00:55:59.420 --> 00:56:00.520 in terms of host defenses

997 00:56:00.520 --> 00:56:03.390 and host defenses being slightly weakened at that time

998 00:56:03.390 --> 00:56:05.960 or potentially direct relationships

999 00:56:05.960 --> 00:56:08.410 with virus survival or potentially you know,

1000 00:56:08.410 --> 00:56:11.220 seasonal differences in behavior such as aggregation of kids

1001 00:56:11.220 --> 00:56:14.403 in schools in the fall period,

1002 00:56:15.630 --> 00:56:20.130 but I think trying to bring that to bear

1003 00:56:20.130 --> 00:56:23.590 and directly predicting the incidence

1004 00:56:23.590 --> 00:56:25.240 of the SARS-CoV-2 virus

1005 00:56:25.240 --> 00:56:27.510 at this time is gonna be very difficult

1006 00:56:27.510 --> 00:56:29.610 because I think the biggest factor

1007 00:56:29.610 --> 00:56:33.713 kind of underlying transmission right now is differences,

1008 00:56:35.070 --> 00:56:37.810 I mean we have a virus in which everybody is susceptible

1009 00:56:37.810 --> 00:56:40.200 and so it's gonna be able to spread efficiently

1010 00:56:40.200 --> 00:56:43.190 kind of regardless of climate conditions

1011 00:56:43.190 --> 00:56:46.780 across different settings and so I think

1012 00:56:46.780 --> 00:56:49.500 that climate is gonna play kind of less of a role now

1013 00:56:49.500 --> 00:56:54.090 in terms of determining when these seasonal peaks happen

1014 00:56:54.090 --> 00:56:57.616 compared to just all the other factors

1015 00:56:57.616 --> 00:57:01.240 in terms of social distancing and other interventions

1016 00:57:01.240 --> 00:57:04.820 and when some of these things are relaxed,

1017 00:57:04.820 --> 00:57:06.590 when people become complacent

1018 00:57:06.590 --> 00:57:08.840 and stop you know taking all the precautions

1019 00:57:08.840 --> 00:57:10.200 that they've been taking

1020 00:57:10.200 --> 00:57:12.520 during the summer months for example,

1021 00:57:12.520 --> 00:57:17.230 more so than the role that climate is gonna play right now.

1022 00:57:17.230 --> 00:57:19.610 So I think it's really a situation we're gonna have

1023 00:57:19.610 --> 00:57:23.260 to wait and see kind of what are the major climate drivers

1024 00:57:23.260 --> 00:57:24.679 of the SARS-CoV-2 virus

1025 00:57:24.679 --> 00:57:27.383 and how much is it really modulating transmission.

1026 00:57:29.460 --> 00:57:31.860 - Thanks, that's very insightful.

1027 00:57:31.860 --> 00:57:36.500 So I think we have some time from the audience

1028 00:57:36.500 --> 00:57:38.420 to ask a questions.

1029 00:57:38.420 --> 00:57:42.740 So there's one question was wondering,

1030 00:57:42.740 --> 00:57:45.250 if the terms adjusted for the annual

1031 00:57:45.250 --> 00:57:50.250 and the bi-annual pattern only account for seasonality,

1032 00:57:50.320 --> 00:57:52.083 how about the long-term change?

1033 00:57:53.564 --> 00:57:54.480 And a further question is

1034 00:57:54.480 --> 00:57:57.430 if one disease shows a bioannual pattern,

1035 00:57:57.430 --> 00:58:00.283 why still use the annual term in the model?

1036 00:58:03.400 --> 00:58:05.188 - Okay, so that's a, I think very--

1037 00:58:05.188 --> 00:58:06.181 - Very technical.

1038 00:58:06.181 --> 00:58:07.243 - Yeah, technical question,

1039 00:58:07.243 --> 00:58:10.530 it's a you know, difficult question to answer

1040 00:58:10.530 --> 00:58:12.890 kind of directly related to,

1041 00:58:12.890 --> 00:58:16.421 I'm not sure kind of which disease this is in relation to.

1042 00:58:16.421 --> 00:58:21.421 If it's specifically around kind of rotavirus in Bangladesh,

1043 00:58:24.180 --> 00:58:27.610 certainly I think that there is potentially

1044 00:58:27.610 --> 00:58:29.610 also long-term trends happening

1045 00:58:29.610 --> 00:58:31.460 in transmission rates over time

1046 00:58:31.460 --> 00:58:35.330 and often we do need to account for these potential

1047 00:58:35.330 --> 00:58:38.420 like linear or long-term trends happening

1048 00:58:38.420 --> 00:58:39.870 in baseline incidents over time

1049 00:58:39.870 --> 00:58:41.470 which may be important as well

1050 00:58:41.470 --> 00:58:43.210 and it’s often something that we do

1051 00:58:43.210 --> 00:58:46.370 kind of explore incorporating into the models

1052 00:58:47.320 --> 00:58:49.760 and is potentially able to explain

1053 00:58:49.760 --> 00:58:51.720 some of these you know, unusual shifts

1054 00:58:51.720 --> 00:58:54.520 that we might see for example from the biannual

1055 00:58:54.520 --> 00:58:57.790 to more annual epidemics happening in Bangladesh

1056 00:58:57.790 --> 00:59:01.040 in conjunction with the sort of the decrease in birth rate,

1057 00:59:01.040 --> 00:59:02.579 we’re probably also seeing a decrease

1058 00:59:02.579 --> 00:59:05.693 in potentially transmission rates over time in that setting.

1059 00:59:08.070 --> 00:59:09.800 But in the question around

1060 00:59:09.800 --> 00:59:13.100 kind of why do you incorporate both biannual

1061 00:59:13.100 --> 00:59:15.093 and annual terms in a model.

1062 00:59:16.450 --> 00:59:18.320 The reason for that is often

1063 00:59:18.320 --> 00:59:20.500 because if you’re only incorporating a

1064 00:59:20.500 --> 00:59:22.370 sort of biannual harmonic term

1065 00:59:22.370 --> 00:59:24.210 that assumes inherently

1066 00:59:24.210 --> 00:59:28.760 that the size of the two peaks is the same

1067 00:59:28.760 --> 00:59:31.490 whereas when you add an annual harmonic,

1068 00:59:31.490 --> 00:59:35.880 it allows for two peaks of varying size happening

1069 00:59:35.880 --> 00:59:39.870 throughout the year and so it can sort of basically lead

1070 00:59:39.870 --> 00:59:42.050 to a larger peak and a smaller peak throughout the year,

1071 00:59:42.050 --> 00:59:43.540 whereas if you only have a biannual term,

1072 00:59:43.540 --> 00:59:45.720 you can only have those two peaks

1073 00:59:45.720 --> 00:59:47.670 by definition have to be the same size.

1074 00:59:48.770 --> 00:59:50.200 - Great, thank you.

1075 00:59:50.200 --> 00:59:55.200 So I think we have reached the end of this seminar

1076 00:59:55.760 --> 00:59:59.730 and thank you Gina for this wonderful presentation

1077 00:59:59.730 --> 01:00:02.020 and thank you all for coming.

1078 01:00:02.020 --> 01:00:05.970 Our recording will be available later

1079 01:00:05.970 --> 01:00:10.910 and we will have our next seminar in November.

1080 01:00:10.910 --> 01:00:15.140 So looking forward to see you soon, bye.

1081 01:00:15.140 --> 01:00:16.097 - Great, thank you.