COVID-19 Instructor Notes

**Epidemic Modeling:**

Biological settings are often very complicated, making it a common practice in biological modeling to use models designed for very general settings rather than for specific ones. Students of mathematical epidemiology generally study generic models, while researchers in mathematical epidemiology often create much more complicated models designed for the specific features of the target disease. This module uses a complicated COVID-19 module. Modules 1 and 2 use the simpler SIR and SEIR models.

**Our COVID-19 Model:**

The SEIR model has four classes: Susceptible, Exposed (latent)[[1]](#footnote-1), Infectious, and Removed. This is a reasonable starting point for COVID-19. However, it fails to include several key features. We need to address the threat of having too many patients requiring hospitalization at the same time and the significant proportion of infectives who are asymptomatic. Asymptomatics, symptomatics, and hospitalized symptomatics are all grouped together in an SEIR model. We also need to clearly distinguish people removed from the system through recovery/vaccination from people removed by dying. To be useful for COVID-19, our model needs to be SEAIHRD rather than SEIR (Susceptible-Exposed-Asymptomatic-(symptomatic)Infectious-Hospitalized-Recoverd-Deceased). This is much too complicated to expect students to do the spreadsheet coding themselves. Students will need to code experiments, but not the model itself.

**Sandbox Modeling:**

In many contexts, the term “sandbox” has come to mean “a place for free exploration of ideas.” The workbook has a sandbox top sheet that serves as a “model user interface.” Students program experiments by entering data into color-coded cells in the MUI, read the results from some other color-coded cells and two graphs, and then answer questions that focus on making sense of the results.

**Using Models:**

To paraphrase a quotation from Albert Einstein: “Nobody believes a model except the person who created it; everybody believes data except the person who collected it.” In reality, both are very useful, but must be used cautiously.

Models are not a mathematical expression of reality. They are a mathematical representation of a caricature of reality. They are based on assumptions that are taken from general principles we believe apply to the given setting. Features of the real-world setting can be oversimplified or neglected altogether. Is COVID-19 seasonal, like influenza, or is the rate of spread largely independent of the season? We don’t know. Our model assumes no seasonality.

Data comes from measurements, which can be very accurate in physics and astronomy but are often inaccurate in medicine and biology. Even things that are seemingly easy to measure, like the number of patients hospitalized with COVID-19 or the fraction of hospitalized patients who die, can be difficult to determine accurately. [[2]](#footnote-2) The most important parameter in any COVID-19 model, the basic reproductive number, has been estimated to be anything from about 2.5 to 8.

These cautions do not mean that models are useless. As more is learned about a real-world setting, researchers can improve their models with better assumptions and parameter estimates. Since this module was first posted as version 1.0 in May 2020, there have been two significant revisions; hence, this is version 1.2. Eventually vaccination will be added in the development of version 2.0. Even though a model might not give accurate results, there are still reasons to use it. Whereas physics experiments can be repeated with varying scenarios, epidemics and other biological phenomena can only be played out once. We can’t set up real experiments to determine what social policies will manage COVID-19 best. The only way to get any insight into the role of social policies is to use models. We just need to remind ourselves that models do not tell us what will happen. When we study a model, we are learning the behavior of the model itself, and we can only do our best to see that the model represents the real-world scenario as closely as we can manage. Then we can establish public policies based on model predictions because we have nothing better to use.

**Using the S3 Module:**

This module gives instructors a box of tools to use in guiding their students to explore the behavior of the COVID-19 pandemic. It includes an introductory Powerpoint presentation (S3-1), a student notes document (S3-2), a spreadsheet workbook (S2-3), a set of instructions for using the workbook (S2-4), and a document with questions for students to address using the completed spreadsheet and targeted modifications (S3-5). An answer key (S3-6) is available on request (write Glenn Ledder at gledder.unl.edu). Feel free to write to Professor Ledder with any questions, comments, or recommendations.

1. “Exposed” is a misleading term, since it actually refers to individuals who have already caught the disease but are not yet contagious. “Latent” is a more accurate term. [↑](#footnote-ref-1)
2. In the COVID-19 pandemic, many states have not kept track of the number of patients hospitalized. [↑](#footnote-ref-2)