Infectious Simulation in University Environment (ISSUE) Documentation

Infectious Spread Simulation in University Environment (ISSUE) is a browser-based interface that can be used to simulate COVID-19 infection spread in a room at the University of Calgary.

Room Selection Interface:

The collapsible sidebar to the left of the main page contains the room selection interface as shown in Figure 1.

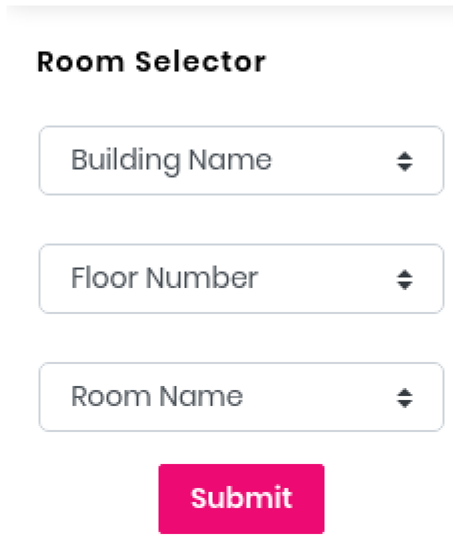

Figure 1: Room selection interface

The interface is used to select a room on campus. There are 3 dropdown menus you should select from in order of building, floor, and finally room. The options will not be visible unless chosen in that order, they will be hidden as shown in Figure 2:

Figure 2: Hidden dropdown selections

- Building: This dropdown menu lets you select a building on campus e.g. Engineering, Earth Sciences, Science Theatres, and so on.

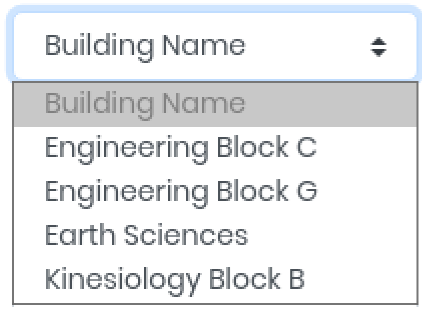

Figure 3: Available selections for building dropdown

- Floor: This dropdown menu lets you select a floor for the particular building that was previously chosen.

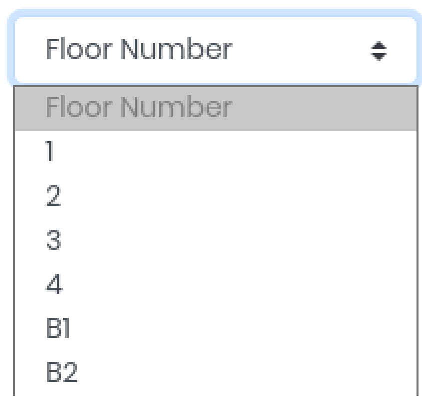

Figure 4: Available selections for floor dropdown

- Room: This dropdown menu lets you select a room that is available on the selected floor of the chosen building.

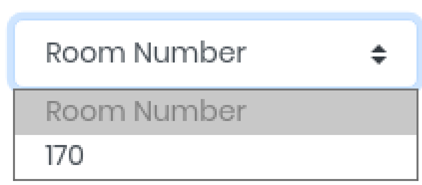

Figure 5: Available selections for room dropdown

Once the selections are made you must click the submit button to load the seat selection interface.

Seat Selection Interface:

The seat selection interface enables the user to directly indicate the seats on which they want to place the agents and whether these placed agents are to be treated as infected with the infectious disease or not. The user has two options for inputting their placements (these two input methods can work in tandem):

1. **Manual Selection:** using the *mouse*, the user can directly select the seats where they wish to place the actors. Clicking on the same seat repeatedly will cycle through 3 states:

    a. **White:** seat is empty
    b. **Green:** seat contains a normal (un-infected) agent
    c. **Red:** seat contains an infected agent

2. **Randomized Selection:** using the *slider,* the user can manipulate the:

    a. **Upper bound:** to select the **total** number of agents to place in the room (agents are selected in a *deterministic order* that is generated randomly at initialization), and the
    b. **Lower bound:** to select the number of **infected** agents to place at random (at each step).

    The *red region* on the slider indicates a range of total agents that *exceeds* the maximum recommended **pandemic occupancy.**

Dragging both thumb sliders all the way to the left will reset all seat selections.

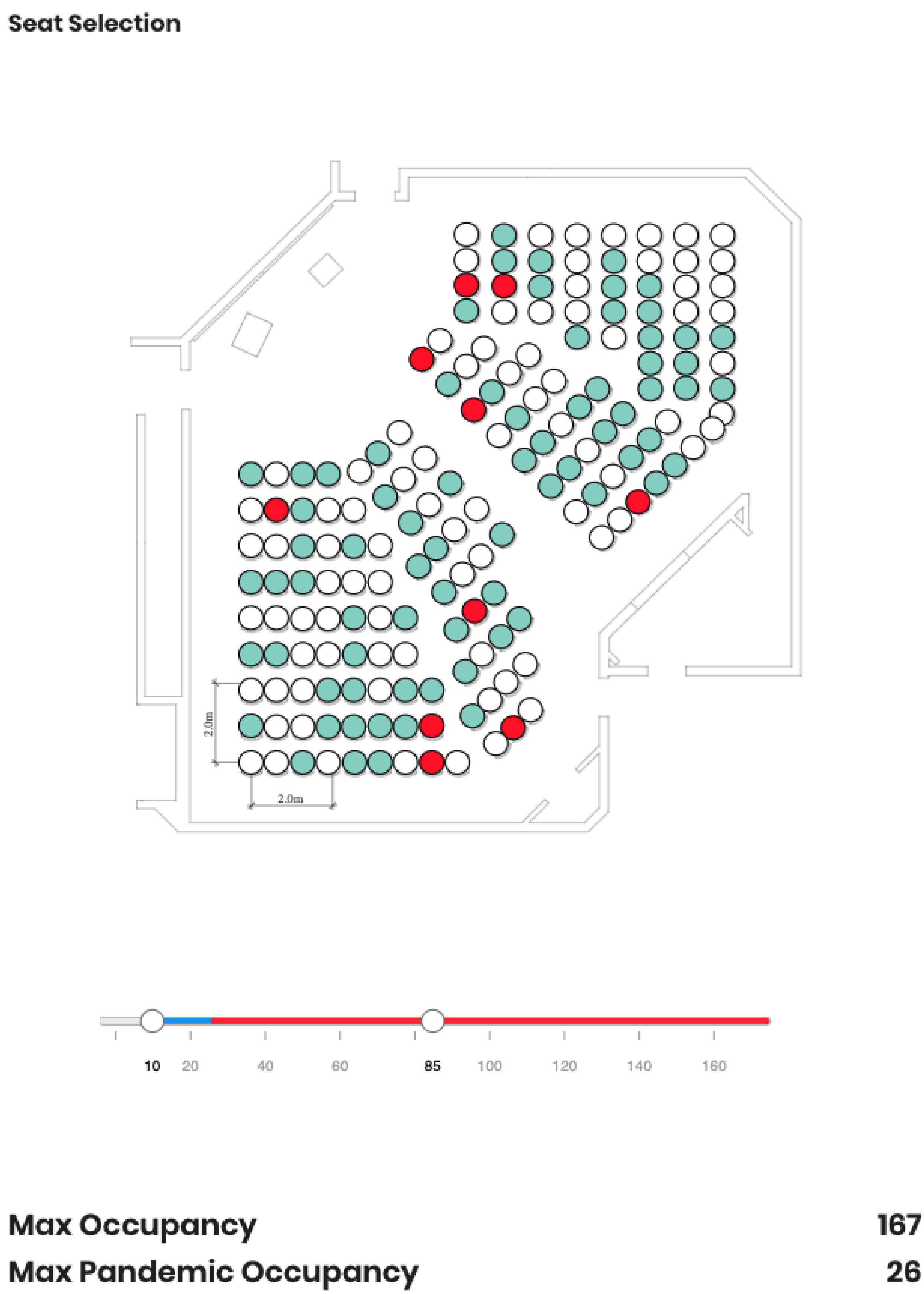

Figure 6: Seat selection interface

Infection Parameter Settings:

The infection parameter settings (Figure 7) are used to emulate a real-world scenario as much as possible. This includes radio buttons that can be clicked to set the **Personal Protective Equipment (PPE)** and an input spinner to set the **length of stay (duration)** in the specified room.

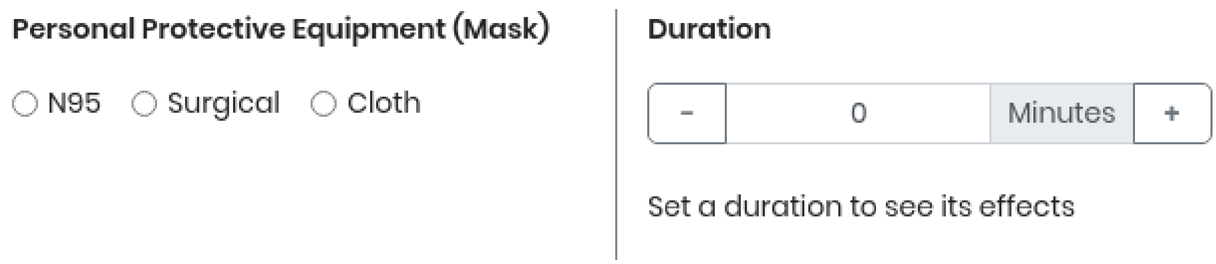

Figure 7: Infection parameter settings

There are 3 different masks to choose from, each with varying effectiveness:

- **N95** - 89.6%
- **Surgical** - 33.3%
- **Cloth** - 11.3%

The duration takes an input in **minutes**, either by *keyboard entry* or *clicking the plus and minus buttons*, with a maximum allowed duration of **180 minutes**. If you are inputting the duration using a keyboard, the enter button must be pressed in order to set the duration.

COVID-19 Model:

A statistical model used to calculate the risk of transmission for the COVID-19 virus, in the event that an infected population is present along with a non-infected population. This model is heavily based on data derived from the research article, "Risk of Coronavirus Disease 2019 Transmission in Train Passengers: an Epidemiological and Modelling Study," which relates the attack rate of the virus with spatial distance. By using mathematical techniques, such as interpolation and curve fitting, with the data presented in this paper, an equation relating the attack rate with the euclidean distance between an infected and non-infected individual was derived. However, due to insufficient data, the derived equation will only apply to distances less than 3.3m. It is assumed any non-infected individuals beyond a distance of 3.3m from an infected individual will have an attack rate of 0.05%, and beyond 6.0m will have an attack rate of 0%.

$$y(x) = \begin{cases} 0.235x^6 - 3.3677x^5 + 19.429x^4 - 57.456x^3 + 91.311x^2 - 73.517x + 23.52 & if\ x < 3.3m \\ 0.05 & if\ 3.3m \leq x \leq 6.0m \\ 0 & if\ x > 6.0m \end{cases} \qquad (i)$$

Where *x* is the Euclidean distance between the infected and non-infected individual in metres.

In the case of multiple infected individuals that are within the vicinity of a non-infected individual, the probability rule for the union of independent events is applied for the total attack rate. For example, the total attack rate for a non-infected individual, *y(x)*, that is within the vicinity of infected individuals *A*, *B*, and *C* is as follows:

$$y(x) = P[y_A(x) \cup y_B(x) \cup y_C(x)]$$

$$y(x) = P[y_A(x)] + P[y_B(x)] + P[y_C(x)] - P[y_A(x) \cap y_B(x)] - P[y_A(x) \cap y_C(x)] - P[y_B(x) \cap y_C(x)] + P[y_A(x) \cap y_B(x) \cap y_C(x)] \quad (ii)$$

Where $y_A(x)$ is the attack rate on the non-infected individual from infected individual *A*, $y_B(x)$ is the attack rate on the non-infected individual from infected individual *B*, and $y_C(x)$ is the attack rate on the non-infected individual from infected individual *C.*
If more infected agents are selected, the above equation would be modified to add the attack rate from the new infected agents and subtract the intersections of all the infected agents.

If a duration of time is specified, the total attack rate is increased by a factor of *T*:

$$y(x) = y(x) \times T \qquad (iii)$$

$$T = \frac{0.121 + 0.022t^2}{100} + 1 \qquad (iv)$$

Where *t* is the duration specified in minutes. A value of 1 is added to *T* for mathematical purposes when increasing the attack rate in equation (*iii*). The actual multiplier will be the fraction term in equation (*iv*).
If no duration of time is specified, this equation is skipped when calculating the attack rates, and the resulting attack rates from the model is a representation for an instant in time.

If the type of PPE/mask is selected, the total attack rate is decreased by multiplying it by *M*:

$$y(x) = y(x) \times M \qquad (v)$$

$$M = 1 - m \qquad (vi) \qquad and \qquad m = \begin{cases} 0.896 & For\ N95\ masks \\ 0.333 & For\ surgical\ masks \\ 0.113 & For\ cloth\ masks \end{cases}$$

Where *m* is the type of mask selected.
If no mask is selected, this equation is skipped when calculating the attack rates, and the resulting attack rates from the model is a representation when agents are wearing no masks.

Temporal Data:

A line graph showing the temporal effect on the attack rates. Essentially, as the time spent in the particular room starts increasing, the attack rates will also increase proportionally. These graphs simply show how the attack rate will increase with time, not necessarily specific to the room, but more generally how the COVID-19 attack rate is affected by time. The time spent in the room can be selected using the Duration Field shown in Figure 8. The temporal graphs will start from Time = 0 and continue until the time specified in the duration field. Sample temporal graphs can be seen in Figure 9 and 10.

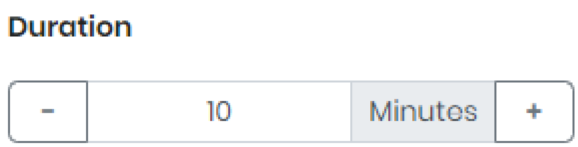

Figure 8: Showing the duration field where users can input duration spent within a room

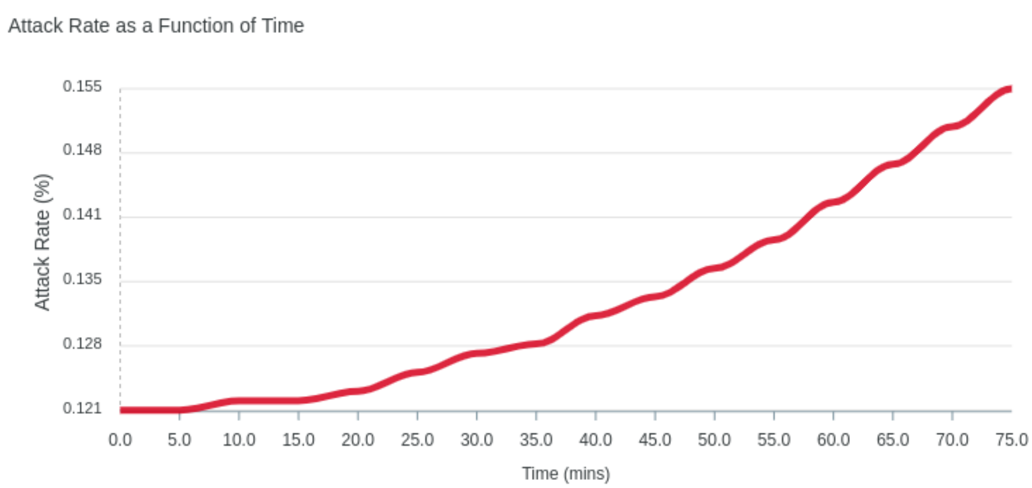

Figure 9: Attack rate multiplier for 75 minutes

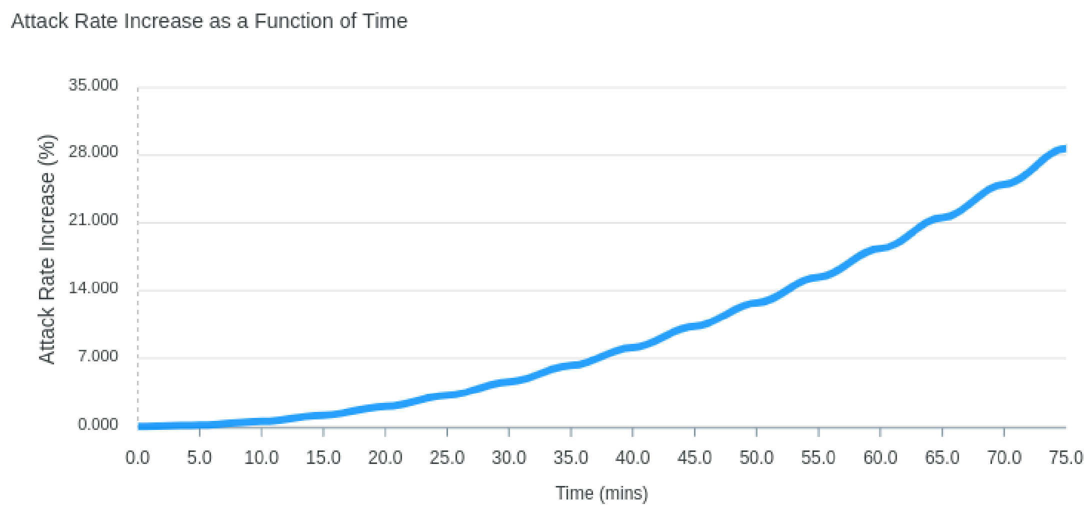

Figure 10: Attack rate increase (%) for 75 minutes

Figure 9 and 10 use aspects of the same temporal equation to show how the attack rate changes with respect to time. To give the user as much information as possible, both graphs are shown in the application with the ability to zoom and pan each graph.

Figure 9 shows how the temporal attack rate increases with time. To calculate the total attack rate in the model, the temporal attack rate is manipulated into a multiplier, so the spatial attack rate can easily be multiplied with the temporal attack rate. Refer to the Covid-19 Model section, equation (*iv*) for more details on how this is calculated. This temporal multiplier would be the value used to find the total attack rate in the model, as seen in equation (*iii*).

Figure 10 shows the *percentile* increase in attack rate with time using the following equation that was developed from the data in Figure 9.

$$Attack\ Rate\ Increase\ (\%) = 0.0051t^2 \qquad (vii)$$

Where *t* is the duration of time in minutes.
This shows how much the attack rates have increased in relation to the original value with no duration set (*t* = 0 minutes). Equation *(vii)* is used for the generation of the Attack Rate Increase graph only, and is not used in the Covid-19 model for any total attack rate calculations.

Heatmap:

Provides a high-level view of the infection rates across the room. This feature updates in real time as the seat selection interface has students, and infected students placed within the room. Follows the typical heat map format of using a red shade to indicate the highest probability of infection. The rate decreases as an individual is further away from that “hot” zone. Which is indicated by changing colors to eventually where the seats have no shading on them. A sample heat map can be seen in Figure 11.

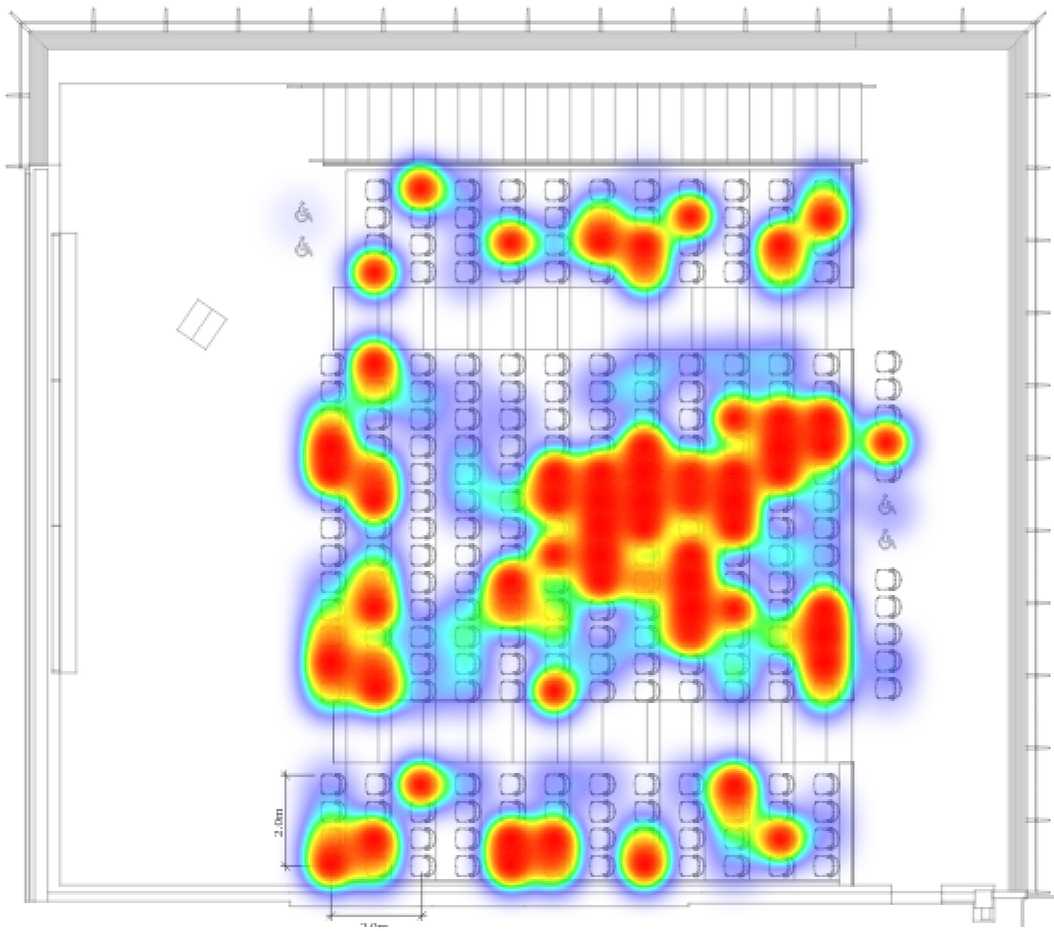

Figure 11: Sample heat map showing attack rates of students sitting in a lecture hall (ENC 170)

Contact Information

If you require additional support or help, please contact the Biometric Technologies Laboratory (BT Lab) at the following link.