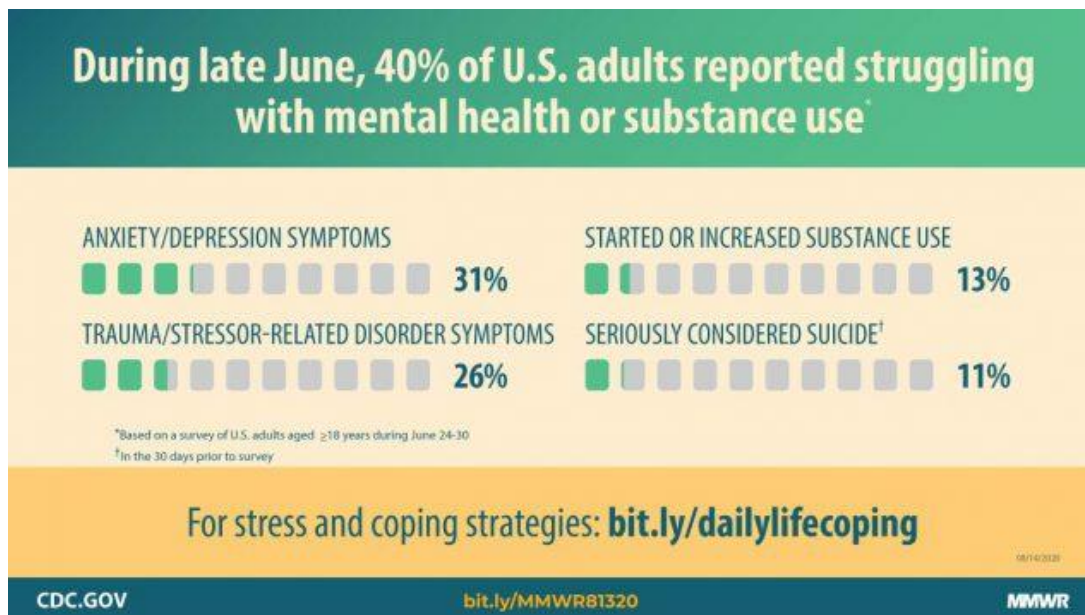


PerIn this report we will summarize our project and present our findings. We will go over our roadmap, research, coding, and our data. Our project went in this order: research, coding, running simulations, formatting our data, and finalizing our poster and report.

During the research phase, we used sources like the Center for Disease Control and Prevention and the National Library of Medicine to find factual information to use in our project. To create our model, we had to ask a good deal of questions. The question we started with was: What is the prevalence of mental illness before the COVID-19 pandemic and how did it change after the pandemic? In 2019, a study (NIH, 2023) showed that 20% of Americans experienced mental illness—primarily depression or an anxiety disorder—and a 2020 study (CDC, 2021) showed that 40% of Americans are struggling with anxiety, grief, or isolation, as shown in Figure 1.



**Figure 1. Graphic depicting adults' struggles with mental health and substance use, as presented in a Centers for Disease Control Weekly Mortality and Morbidity report in August of 2020 (CDC, 2020).**

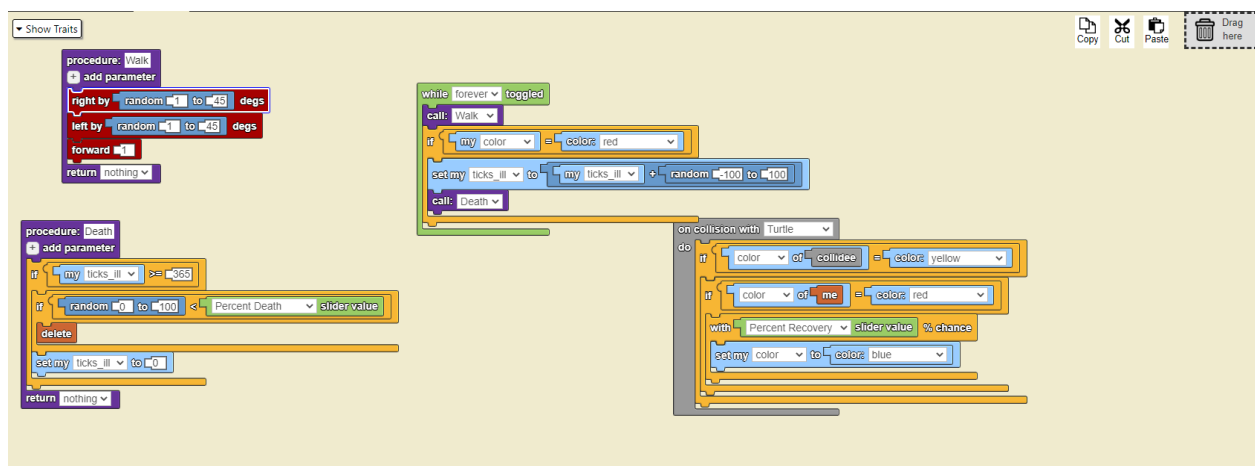
While both of these surveys only questioned adults, young people have been disproportionately affected by the pandemic. When your life—and your social life specifically—revolves around school, the lack of school and its social interactions can take a toll on your mental health. When

kids and teens are faced with challenges, many of us turn to our classmates and teachers for support. Despite how the pandemic disrupted school connections—for teachers and students alike—some kids still found ways to connect through online schooling. In a 2021 study (CDC, 2022), researchers found that “Youth who felt connected to adults and peers at school were significantly less likely than those who did not (feel connected) to report persistent feelings of sadness or hopelessness”. While this may be true, it’s important to note that less than half (47%) of participants reported feeling close to other people at school during the pandemic. Even as many of us return to physical school, the pandemic has left its permanent mark on us all, hence the youth mental health crisis we have today.

One of the positive effects of Covid was that the conversation around mental health has opened up, but the world is still struggling with a lack of mental health providers. What is the ratio of mental health providers to patients? This was one of our most important questions. Answering it was essential for creating a realistic model. Our research shows that there is roughly 1 mental health provider for every 2500 people (Country Health Ratings & Roadmaps, 2023). Initially, we planned to include a total population of 100 people, but that wouldn’t work since 100 people wouldn’t equate to 1 provider. Thus, we increased our total population to allow for at least one provider. We then used these statistics to create variables that gave a realistic picture of the world. These variables included: the ratio of therapists to people, the percentage of people with anxiety and depression, and how often people recover with the help of therapy. Once we established our variables we were ready to start coding.

We based our coding off of an epidemiological model. The epidemiological model helped us illustrate how sadness (anxiety and depression) spreads throughout the community and how therapy can help people recover. Essentially, sadness was treated as a disease that could be cured (by therapy) or lead to death (our definition of adverse outcomes). We used colors to

represent the different categories of people (i.e. healthy and sick and mental health providers/therapists). Red was for people with anxiety and depression (sad people), blue represented people without anxiety and depression (happy people), and black was for therapists. After clearly identifying our groups, we operationalized our variables. We used sliders to control how many people in each group were present when the simulation started. In our model, when a sad person encountered a therapist, they had a chance at recovery. Every 30 days individuals with anxiety or depression randomly experienced adverse outcomes (death in our model). We coded for probability sliders that controlled the starting number of sad people, happy people, and therapists. We set our sad person rate to 40% and our number of therapists to 1. We also included an adverse outcome slider which was set to 7% (the current risk of suicide among individuals with mental health issues). Every 10 simulations we raised the number of therapists by 1 until we got to 5. After trials 1-5, we jumped to 10 therapists. Even though we included sliders for the number of sad/happy people and the rate for an adverse outcome, we decided to keep them the same for all of the trials. These are variables that future simulations may adjust.

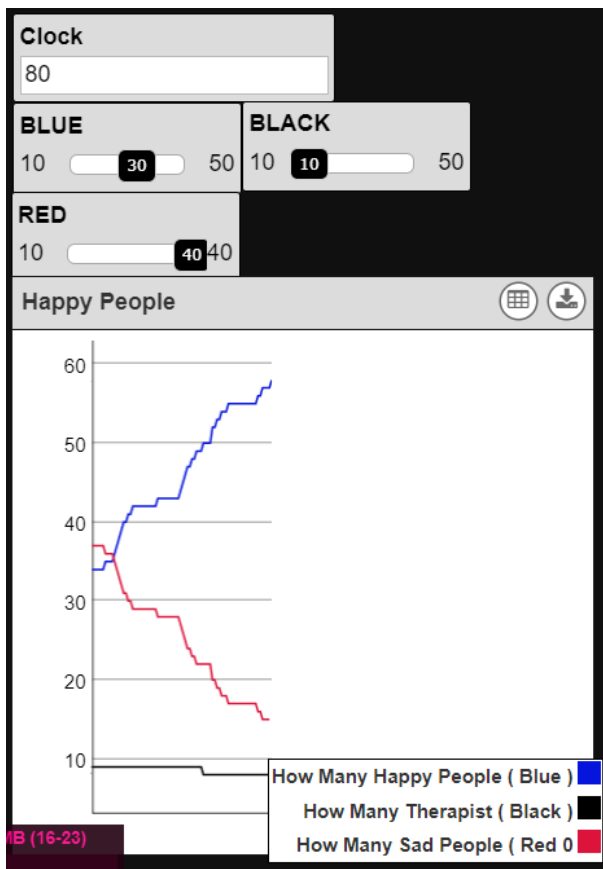


```

when setup pushed
  clear terrain
  delete everyone
  clear line graph Population
  set clock to 0
  create Healthy Population slider.value Turtle (s)
  each do
    set my color to color red
    set my licks to 0
  create Healthy Population slider.value Turtle (s)
  each do
    set my color to color blue
  create Therapist slider.value Turtle (s)
  each do
    set my color to color yellow
  scatter everyone
  scatter everyone

while forever toggled
  set Clock data box to clock
  set Blue data box to count Turtle within 150 steps with color = color blue
  set Red data box to count Turtle within 150 steps with color = color red
  set Everyone data box to count Turtle within 150 steps
  Add data to line graph Population for Healthy
  x-axis: clock y-axis: count Turtle within 150 steps with color = color blue
  Add data to line graph Population for Sick
  x-axis: clock y-axis: count Turtle within 150 steps with color = color red
  Add data to line graph Population for Population
  x-axis: clock y-axis: count Everyone within 150 steps
  if clock = 365
    toggle forever to off for everyone
  
```

**Figure 2.** Snapshot of our code in StarLogoNova. This code was based upon an epidemiological model. Adverse outcomes reflect the risk of suicide among individuals suffering from anxiety and depression.

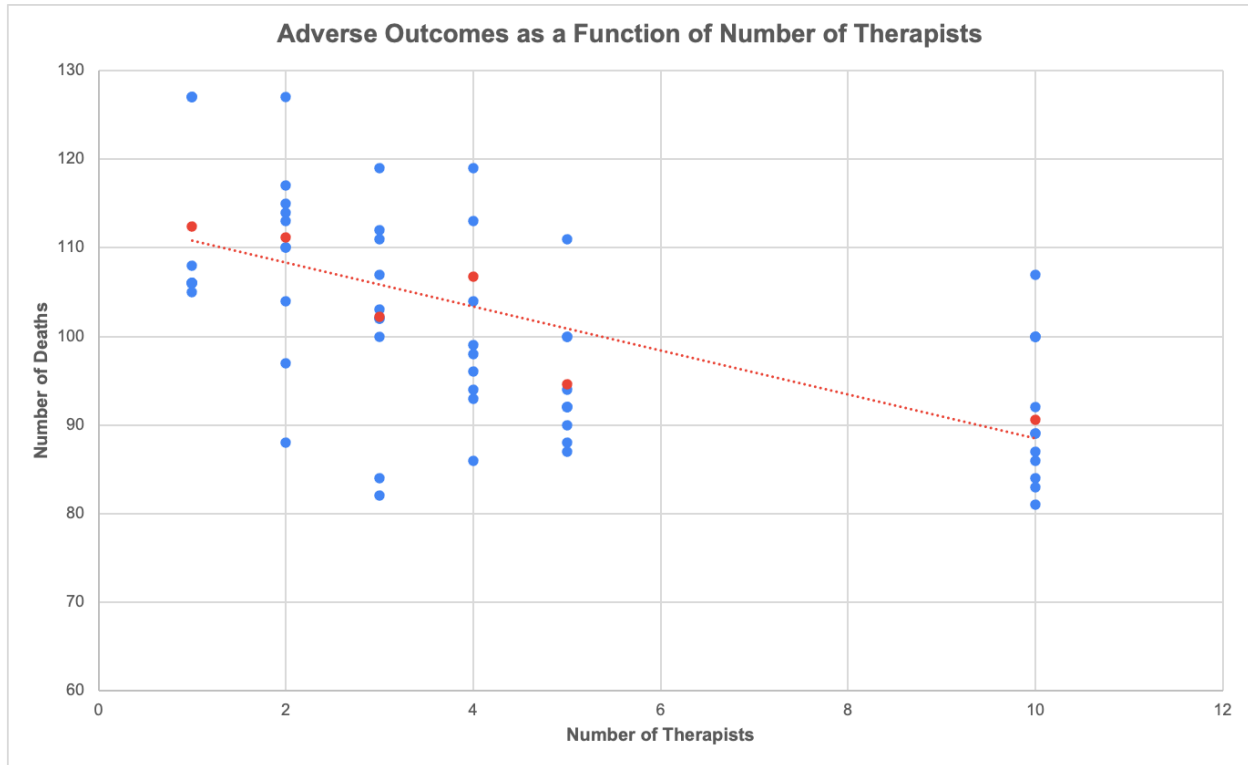


**Figure 3.** A sample of the output we collected in StarLogoNova. These measures were then aggregated in Microsoft Excel to allow for data analysis.

Once our coding was complete, we ran 60 simulations. The only variable that we adjusted was the number of therapists per 2500 people. The other sliders (proportion of the population with mental health disorders, risk of suicide or other adverse outcomes) were held at the values specified previously, as those represent the state of mental health in the United States. We ran ten simulations for varying numbers of therapists, starting with one therapist per 2500 people and ending with 10 therapists per 2500 people (therapist numbers included 1, 2, 3, 4, 5, and 10). We collected population data from each simulation and consolidated it into one dataset. Specifically, over time (each simulation covered 365 “days”) we tracked the number of “sick” individuals (those with mental health disorders), the number of healthy individuals, and the total population size. Sick individuals had the opportunity to experience an adverse outcome (death in our model), to remain sick, or to become healthy through contact with a therapist. Our consolidated data allowed us to determine the number of deaths per 2500 people across different numbers of therapists. We also calculated the standard deviation across each number of therapists. This data is presented below in Table 1. This information is also portrayed graphically in Figure 4. There is a clear downward trend in the average number of deaths across trials. In other words, when there are more therapists present, there are fewer adverse outcomes (deaths).

<b>Number of therapists</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>10</b>
<b>Number of deaths</b>	105	113	84	104	111	100
	106	115	100	113	100	100
	106	104	102	119	100	100
	106	110	102	166	87	81
	106	110	103	86	88	83
	106	114	107	93	90	84
	108	114	111	94	92	86
	127	117	112	96	92	87
	127	127	119	98	92	89
	127	88	82	99	94	89
<b>Average Deaths</b>	112.4	111.2	102.2	106.8	94.6	89.9
<b>Standard Deviation Deaths</b>	10.10170503	10.05319186	11.65999809	22.95309226	7.229568913	7.400450437

**Table 1. Summary of the data from our simulations. We ultimately tracked the number of deaths across different numbers of therapists.**



**Figure 4. Adverse outcomes (death) as a function of the number of therapists. Each blue dot represents a single trial. The red dots represent the average number of deaths across all trials with that number of therapists. We've also included the trendline.**

Once we aggregated our data, we performed an analysis of variance (ANOVA) on our data, using an online One-Way ANOVA calculator. Basically, an analysis of variance compares the means from two or more 'treatment groups' to determine if those means are similar or different. The 'treatment groups' for our data are the numbers of therapists. The results of our ANOVA are below in Table 2. Our results demonstrate that we *do* have significant differences (at an alpha level of 0.05) between groups, specifically when comparing one therapist to five therapists.

Result Details				
<i>Source</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	
Between-treatments	1943.336	4	485.834	<i>F</i> = 2.74031
Within-treatments	8155.4091	46	177.2915	
Total	10098.7451	50		

**Table 2. One-way ANOVA results. The differences between treatment groups are significant, with an f-ratio value of 2.74031 and a p-value of 0.039772.**

Additionally, the online ANOVA calculator allowed us to examine post-hoc comparisons using Tukey HSD. What this means is that each possible pair of treatment groups was compared, using the means and standard deviations, to determine which groups differ significantly. Those results are summarized in Table 3. The significant differences in means are evident when the simulations with one and five therapists are compared. In other words, there are *more* deaths in trials with only one therapist per 2500 people as compared to trials with five therapists. We have not included the comparisons with 2, 3, or 4 therapists.



<i>Pairwise Comparisons</i>		HSD <sub>.05</sub> = 16.7503 HSD <sub>.01</sub> = 20.3855	Q <sub>.05</sub> = 4.0148    Q <sub>.01</sub> = 4.8861
T <sub>1</sub> :T <sub>2</sub>	M <sub>1</sub> = 112.40 M <sub>2</sub> = 109.91	2.49	Q = 0.60 ( <i>p</i> = .99313)
T <sub>1</sub> :T <sub>3</sub>	M <sub>1</sub> = 112.40 M <sub>3</sub> = 103.30	9.10	Q = 2.18 ( <i>p</i> = .54108)
T <sub>1</sub> :T <sub>4</sub>	M <sub>1</sub> = 112.40 M <sub>4</sub> = 106.80	5.60	Q = 1.34 ( <i>p</i> = .87600)
T <sub>1</sub> :T <sub>5</sub>	M <sub>1</sub> = 112.40 M <sub>5</sub> = 94.60	17.80	Q = 4.27 ( <i>p</i> = .03220)

**Table 3. Tukey HSD comparisons. The groups with one and five therapists are significantly different with a p-value of 0.03220**

So what does all of this mean? Our background research and the data from our simulation clearly highlight that mental health issues are prevalent at a fairly high rate, have measurable negative effects, and may be positively affected by having access to a mental health provider, such as a psychologist, social worker, or counselor. We face an incredible lack of access to mental health providers, with many people living in areas without providers. Our technology may help reduce this, however, with access to mental health apps and professionals virtually. Our simulation highlights that having access to a mental health provider significantly reduces the risk of an adverse outcome (death by suicide). Mental health apps have rapidly increased in the past few years, but it is hard to determine the success of these apps in reducing adverse outcomes. This drives our ultimate (several years') goal - developing a "panic" button, so to speak, which will broadcast an emergency text/message to an individual's pre-loaded social support network. There are also some changes to our model that we would implement if we had more time and resources. These include considerations like having "sad" people actively seek out the

therapist(s), grouping several therapists together in fixed locations (representing physical sites of mental health practices), allowing “happy” people to exert a positive impact on “sad” people, as friends may also help an individual avoid an adverse outcome, and manipulating the other sliders (suicide risk, prevalence of mental health disorders, etc.). While these might give us a more accurate picture of how adverse outcomes might be avoided, they were beyond the scope of both our time and our coding abilities.

This project has also had significant impacts on our knowledge of ourselves. We were surprised by the current statistics on suicide - we thought that the rate of adverse outcomes was much lower than it is. We’ve learned that we have a tendency to procrastinate, and that work is much easier to complete when you pace yourself and manage your time wisely. Reminding our teammates to stay on track was a pivotal part of our project. Our project also taught us about how coding, and specifically mathematical modeling and simulations, are used to gather data when there isn’t a direct way to study a particular phenomenon. We are excited to be able to use these data to achieve our overall goal - a panic button to help people notify their social support system when they are having an acute mental health crisis. The SuperComputing Challenge has allowed us to grow as students, as researchers, and as empathetic members of society.

## **Resources**

**Dorwart, Laura. “Best Mental Health Apps of 2023.” *Verywell Mind*,**

**<https://www.verywellmind.com/best-mental-health-apps-4692902>.**

**Leamey, Taylor. “Best Mental Health Apps for 2023.” *CNET*, CNET, 21 May 2022,**

**<https://www.cnet.com/health/mental/best-mental-health-apps/>.**

**“About Mental Health.” *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 28 June 2021,**

<https://www.cdc.gov/mentalhealth/learn/index.htm#:~:text=Mental%20illnesses%20are%20among%20the,some%20point%20in%20their%20lifetime.&text=1%20in%205%20Americans%20will,illness%20in%20a%20given%20year.>

“Useful Wellness and Mental Health Apps.” *UCSF Department of Psychiatry and Behavioral Sciences*, 5 Oct. 2022,  
<https://psych.ucsf.edu/copingresources/apps>

“The State of Mental Health in America.” *Mental Health America*, 10 January 2023.  
[https://mhanational.org/issues/state-mental-health-america.](https://mhanational.org/issues/state-mental-health-america)

Center For Disease Control. “New CDC Data Illuminate Youth Mental Health Threats during the COVID-19 Pandemic.” *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 31 Mar. 2022,  
<https://www.cdc.gov/media/releases/2022/p0331-youth-mental-health-covid-19.html>.

Nealon, Michele. “The Pandemic Accelerant: How Covid-19 Advanced Our Mental Health Priorities.” *United Nations*, United Nations, 9 Oct. 2021,  
[https://www.un.org/en/un-chronicle/pandemic-accelerant-how-covid-19-advanced-our-mental-health-priorities.](https://www.un.org/en/un-chronicle/pandemic-accelerant-how-covid-19-advanced-our-mental-health-priorities)