The aim of our simulation is to show the effect of different measures that can be put in place to limit the spread of Covid-19, and the impact they have on the death rate, as well as the economy. We decided to create a game-like, user-friendly interface where you take the role of the government, and are taken through six 2-month periods where you must choose which of the five parameters you would like to implement each period. During each period, you are given context in regards to the time of year, then must choose which out of social distancing and facemasks, pubs closing early, non-essential shops closing, borders closing and a full-scale lockdown you would like to implement. It then updates and displays a graph showing how this has affected the death rate. Once you have gone through all six periods, it displays a results window highlighting how well you did in minimising the casualties of the disease and showing the final graph as well as a pie chart with the total and proportional economic impact.

Once you run the program, it opens a welcome screen window. In our code, we have used Tkinter, a GUI which has helped us display the whole program in a user-friendly way by making the console interface cleaner and creating separate windows for the user to work through, allowing them to click buttons and choose options etc. Tkinter was perfect to use, as it works across all main operating systems, and we learnt a lot about how to use it through [1]. The welcome screen (figure 1) introduces the game and includes a button for the user to click on to start the main game, which opens in another window. This was made possible using the window.destroy() Tkinter function [2].

Graphical user interface, text, application

Description automatically generated

*Figure 1 – Welcome screen*

In order to calculate the number of Covid related deaths for each period, we calculated a new R-rate each time based on the measures implemented. We created the table below (figure 2) based on our research to aid in our calculations of how much the R-rate is affected by each parameter in each period of the year.

Table

Description automatically generated with low confidence

*Figure 2 – R-rate factors*

Taking the base as the natural R-rate for that time of year, we then multiplied this by the other numbers for the chosen measures to calculate the user's R-rate for that period. For example, it is very cold in January and February so the natural R-rate is 3.2, then if we chose to implement social distancing and facemasks and non-essential shops closing, these reduce the R-rate by 40% and 30% respectively, as shown in the table, so the applied R-rate for this period would be 3.2\*0.6\*0.7 = 1.344. Once we have this, we multiply by the ‘magic number’ to work out the number of deaths for that period and use this final number for the graph. The magic number was worked out using the average number of Covid cases per month (roughly 250,000) [3], with the assumption that there’s been an equal distribution all year round, multiplied by the death rate of 2% [4], then multiplied by 2 as we worked in two-month periods. The process then repeats through the periods using the R-rate calculated from the previous period as well as the numbers in figure 2.

In an example run through, we have implemented just social distancing and facemasks in the first period, giving an R-rate of 3.2\*0.6 = 1.92. In period 2, we have added closing non-essential shops and closing the borders to the distancing etc. to give 1.92\*2.7\*0.7\*0.7\*0.7 = 1.78 as the R-rate. We then continued as follows:

Period 3 – closing pubs early, closing borders – 1.78\*2.1\*1.7\*0.7 = 4.45

Period 4 – distancing etc., closing borders, lockdown – 4.45\*1.5\*0.9\*0.7\*0.8 = 3.36

Period 5 – distancing etc., closing non-essential shops, closing borders – 3.36\*2.0\*0.8\*0.8\*0.7 = 3.01

Period 6 – distancing etc., lockdown = 3.01\*2.9\*0.6\*0.3 = 1.57

Chart

Description automatically generatedGraphical user interface

Description automatically generatedHere are some of the screens working through this:

*Graphical user interface

Description automatically generated with low confidenceFigures 3, 4 and 5 showing periods 2, 4 and 6 of our example run through*

Graphical user interface, text, application, email

Description automatically generatedAs shown in the above figures, we have included a 'next period' button that the user can click on once they've chosen which parameters they want to implement, which takes them to the next couple of months. There is also a ‘help’ button which opens a window (figure 6) giving the introduction to the user’s task and the game instructions. In the final period (figure 5), the 'next period button' changes to a 'results' button. There is also a 'quit' button that ends the program and closes the windows.

*Figure 6 – Help screen*

This example results in the final graph below (figure 7):

Chart, line chart

Description automatically generated

*Figure 7 – Final graph of example run through*

The graphs also show what would've happened had no measures been put in place using the natural R-rate for each period.

To ensure that the user doesn't just choose lockdown every time to keep Covid at bay, we have also included the economic impact of each of the parameters. Through our research, we found how much each of the measures would cost the government.

For example, for non-essential shops closing, that meant that sales dropped by a quarter last year [5], so sales over the whole year went from £394 bn [6] to £295.5 bn (so a cost of 98.5 bn).

Pubs closing early 'halves their takings' [7] so over a year would go from £22.9 bn to £11.45 bn.

The figures for borders closing was influenced by the ‘travel and tourism industry set to lose £37 bn this year’ [8] and finally, lockdown costs around £2.4 bn per day [9]. We then tallied up how many times each was chosen, and therefore found the total cost of the whole year's plan. From this, a pie chart is created showing the proportions of how much each measure has contributed to the stress on the economy.

In this example the total cost was £601.4 bn.

"Total Lockdown" was selected twice and had the biggest effect on the economy. £146 bn\*2 = £292 bn, 100\*292/601.4 = 48.55%.

"Early Closing" was selected once and had the smallest effect on the economy of £1.9 bn, 100\*1.9/601.4 = 0.32%.

"Close International Borders" was selected 4 times. £64 bn\*4 = £256 bn, 100\*256/601.4 = 42.57%.

"Close Non-essential Shops" was selected twice giving a total of £16 bn\*2 = £32 bn, 100\*32/601.4 = 5.32%.

"Distancing & Facemasks" was selected 5 times. £3.9 bn\*5 = £19.5 bn, 100\*19.5/601.4 = 3.24%.

Chart, pie chart

Description automatically generatedThese result in the final pie chart shown in figure 8:

*Figure 8 – Pie chart for example run through*

Finally, once the user has gone through the six periods, they are able to press the 'results' button and a new window is opened with the aid of Tkinter displaying the final graph and pie chart, and also includes a 'replay' button (figure 9).

Graphical user interface

Description automatically generated

*Figure 9 – Results screen*

Graphical user interface, text, application

Description automatically generatedAnother thing we have included is showing some context of social and economic impacts of each of the measures when the mouse hovers over each of the options to inform the user of more information before they make their choices (see figures 10 and 11). This was another feature we added using Tkinter [10].

Graphical user interface, text, timeline

Description automatically generated*Figure 10 – shows what the screen looks like when the mouse hovers above the ‘distancing and facemasks’ button*

*Figure 11 – shows when the mouse hovers over the ‘lockdown’ button*

**References**

[1] https://realpython.com/python-gui-tkinter/

[2] <https://stackoverflow.com/questions/110923/how-do-i-close-a-tkinter-window>

[3] https://coronavirus.data.gov.uk/details/cases

[4] https://coronavirus.data.gov.uk/details/deaths

[5] <https://www.bbc.co.uk/news/business-55625246>

[6] <https://www.economicsobservatory.com/how-coronavirus-affecting-uks-retail-sector>

[7] <https://www.bbc.co.uk/news/business-54246253>

[8] https://www.icaew.com/technical/business-and-management/business-and-management-faculty/business-and-management-magazine/bam-july-august-2020/tourism-in-the-uk-post-covid

[9] https://www.thetimes.co.uk/article/consumer-confidence-at-its-lowest-since-the-financial-crisis-p6phf7x3k?--xx-meta=denied\_for\_visit%3D0%26visit\_number%3D0%26visit\_remaining%3D0%26visit\_used%3D0&--xx-mvt-opted-out=false&--xx-uuid=31c809ae7c2c35a3da4ed2f640b82756&ni-statuscode=acsaz-307

[10] https://stackoverflow.com/questions/16996432/how-do-i-bind-the-enter-key-to-a-function-in-tkinter