The Impact of Help-Seeking for Depression: A Mathematical Model

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Abstract

For years and with the Covid-19 pandemic, mental illnesses such as depression have emerged. According to the World Health Organization, an average of 5% of the population in a country suffers from depression. The investigations address this issue from cultural, economic, and social perspectives, among others, to obtain conclusions about different treatments or ways to approach a solution. We model the influence of people that sought help to treat depression on the depressive population as a *socially-transmitted* disease and use it to explore the effect of that population on another. Will depressed people be affected by the influence of people who sought help for depression? In addition, our model considers the possibility of falling back into depression. Our model fits the estimates and available data to run simulations. The simulations allow us to analyze different effect parameters in our model and give conclusions and recommendations on possible ways to reduce the population that becomes depressed.

Keywords: Depression, mental health, mathematical models, social dynamics

1 Introduction

For years and since the Covid-19 pandemic, different factors have raised awareness about mental illness [5]. According to the World Health Organization (WHO), depression affects approximately 280 million people in the world [3]. It is one of the most common mental disorders, where it is estimated that 5% of adults and 5.7% of those over 60 years of age suffer from it. In addition, adolescents with a major depressive disorder are 30 times more likely to commit suicide [3].

The process of recovering from a mental illness is possible and is a journey rather than a destination [4]. It is not necessarily a return to the asymptomatic stage of the patient's life. The process requires a well-organized support system of family, friends, or professionals and the participation of the patient [5]. In the field of depression, this recovery depends on a remission, an achievement, of low or absent symptom levels, representing the end of the immediate episode [6]. Recovery is persistent remission over a long period and more complete. However, a relapse can occur before and after complete recovery is achieved [6]. Also, evidence-based treatments for depression have effective results, like psychotherapy and pharmacological treatments [6]. Nevertheless, to be incorporated into this process, the patient should seek help.

1

According to [2], help-seeking for mental health problems is an adaptive coping process that attempts to obtain outside help to treat mental health problems. These include seeking help from formal (professional) and informal sources. Timely and appropriate professional help-seeking is essential for detection, treatment, furthermore recovery, and this help-seeking process depends on sociocultural factors in help-seeking behaviors and experiences. Then help-seeking is associated with psychiatric or mental disorders, and analysis of the spread of depression may be a key component.

On the other hand, it is essential to be aware of why people do not seek help for depression. According to [2] in their study, stereotyping, prejudice, and discriminative responses from family and friends can delay or discourage people from seeking help from both formal and informal sources.

In contrast, the support of family and friends makes it easier to seek help from a formal source. These informal sources of help must have the appropriate skills, knowledge, and literacy about depression to recognize mental health problems and the need for professional help and to recommend professional help when needed [2]. Then this invites us to think about the acceptable way to guide depressed people to seek help.

Equally important, educational programs provide helpful support for people in general, as support is often sought from friends of people with mental illness, but they cannot provide adequate help [2]. So maybe raise awareness with testimonials or encourage people with mental illness who have sought help to educate (influence) people who are not seeking help.

In addition to the above, we can think that there is a relationship between seeking help and the influence of people who have sought help for their depression problems, so can we evaluate this phenomenon? Which method can we use?

This work studies the susceptible, depressed population of adults under 60 years of age that does not seek help and seek help and its recovery process in the face of the possibility that people suffer from depression again. The objective is to determine if there is a relationship between the level of influence of people who seek help for the treatment of depression over those who do not and compare their recovery processes. Like the [1] model, we do mathematical calculations and simulations using data to analyze the dynamics in the mentally healthy population who become depressed.

2   Mathematical Model

In this section, we present a mathematical model to study the dynamics in the depressed population. Our model schema is built like other SIR models with a constant population (N). The susceptible class is the mentally healthy people (S) who have never been in a depressive state. The depressed population (D) corresponds to the infectious class. The class of people who look for help and are in the process of recovering is identified as (H). Finally, the people who completed its process ($\tilde{S}$) are also susceptible again.

Then, analyzing how depression appears given a rate of depression, we construct the following graph.
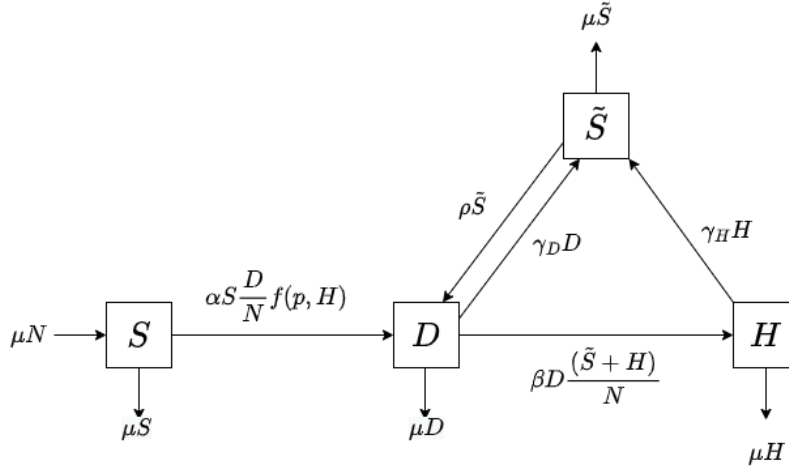
Figure 1: Flow Chart.

The respective parameters are as follows

Table 1: Parameters Definitions

Parameter	Definition
μ	The rate of leaving a class as a result of aging or death
β	Rate of seeking-help
α	Rate at individuals become depressed
ρ	Relapse rate
γ_D	Recovery rate from depression without help
γ_H	Recovery rate from depression with help
p	Rate of influence

The mentally healthy population (S) are susceptible to moving to depression class with the interaction between both classes and the influence of the people who asked for help. Depressed people (D) can use recovery directly or look for help and start a recovery process due to interaction with classes H and $\tilde{S}$. The population that is receiving help (H) can recover. Finally, the people who completed its process ($\tilde{S}$) can relapse.

The following is the system of nonlinear differential equations for our model:

$$\frac{dS}{dt} = \mu N - \alpha S \frac{D}{N} f(p, H) - \mu S, \tag{1}$$

$$\frac{dD}{dt} = \alpha S \frac{D}{N} f(p, H) + \rho \tilde{S} - \frac{\beta D(\tilde{S} + H)}{N} - \gamma_D D - \mu D, \tag{2}$$

$$\frac{dH}{dt} = \frac{\beta D(\tilde{S} + H)}{N} - \gamma_H H - \mu H, \tag{3}$$

$$\frac{d\tilde{S}}{dt} = \gamma_H H + \gamma_D D - \rho \tilde{S} - \mu \tilde{S} \tag{4}$$

The function f is a reducing factor and is given by $f(p, H) = \frac{1}{1 + p \frac{H}{N}}$, where $p \in [0, 1]$. If the influence of the class H is null then $p = 0$, otherwise if class H has total influence then $p = 1$.

2.1 Equilibrium Points

The depression-free equilibrium (DFE) for the system is:

$$(S^*, D^*, H^*, \tilde{S}^*) = (N, 0, 0, 0)$$

2.2 Basic Reproductive Number

To find R_0 we only look at the depressive classes. Let,

$$f_1 = \frac{dD}{dt} = \alpha S \frac{D}{N} f(p, H) + \rho \tilde{S} - \frac{\beta D(\tilde{S} + H)}{N} - \gamma_D D - \mu D,$$

$$f_2 = \frac{dH}{dt} = \frac{\beta D(\tilde{S} + H)}{N} - \gamma_H H - \mu H,$$

and,

$$\mathcal{F} = \begin{bmatrix} \alpha S \frac{D}{N} f(p, H) + \rho \tilde{S} \\ 0 \end{bmatrix}; \mathcal{V} = \begin{bmatrix} \frac{\beta D(\tilde{S}+H)}{N} + \gamma_D D + \mu D \\ -\frac{\beta D(\tilde{S}+H)}{N} + \gamma_H H + \mu H \end{bmatrix}$$

where $\mathcal{F}$ is composed of new depressives in D and H, and $\mathcal{V}$ is composed of all remaining rates.

$$F = \begin{bmatrix} \frac{\partial \mathcal{F}_1}{\partial D} & \frac{\partial \mathcal{F}_1}{\partial H} \\ \frac{\partial \mathcal{F}_2}{\partial D} & \frac{\partial \mathcal{F}_2}{\partial H} \end{bmatrix} = \begin{bmatrix} \alpha & 0 \\ 0 & 0 \end{bmatrix}.$$

Likewise,

$$V = \begin{bmatrix} \frac{\partial \mathcal{V}_1}{\partial D} & \frac{\partial \mathcal{V}_1}{\partial H} \\ \frac{\partial \mathcal{V}_2}{\partial D} & \frac{\partial \mathcal{V}_2}{\partial H} \end{bmatrix} = \begin{bmatrix} \gamma_D + \mu & 0 \\ 0 & \gamma_H + \mu \end{bmatrix} \Rightarrow V^{-1} = \begin{bmatrix} \frac{1}{\gamma_D+\mu} & 0 \\ 0 & \frac{1}{\gamma_H+\mu} \end{bmatrix},$$

$$FV^{-1} = \begin{bmatrix} \frac{\alpha}{\gamma_D+\mu} & 0 \\ 0 & 0 \end{bmatrix}.$$

R_0 is the dominant eigenvalue of FV^{-1}.

$$R_0 = \frac{\alpha}{\gamma_D + \mu}.$$

2.3 Stability

If $R_0 < 1$ the depression-free equilibrium (DFE) is locally asymptotically stable. Generally, this implies a depression-free population. However, analogous to what was found in [10] later, we will find endemics equilibrium if $R_0 < 1$.

3 Results

Given the different references and estimates, we decided to use the following values for the parameters described in the table 1. The $\mu = 0.0000375$ because the World Health Organization estimated that life expectancy is 73 years, $\beta = 0.25$ is the probability that a person with mental illness (depression) receives help in a country with low and middle-income [7], $\alpha = 0.0001369$

based on available data from the World Health Organization of people falling into depression in a year and divided by 365 to obtain an estimate per day, $\rho = 0.00476$ because according to [8] depression relapse is usually seven months, $\gamma_D = 0.00273$ is the estimated average time that a person does not need help to recover from depression because treatment and in-depth analysis of mental illnesses focus on disorders present during 12 months [7], $\gamma_H = 0.00555$ because according to [9] the response to treatment of depression is about six months minimum. We decided to take $p \in [0, 1]$.
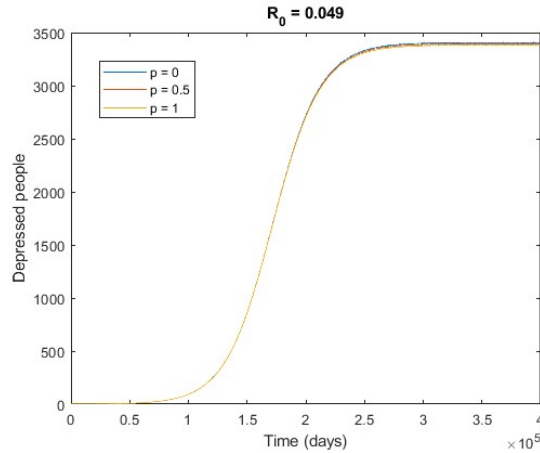
3.1 Varying p

Figure 2: Depressed population when p is varied.

Figure 2 shows that the influence of the people getting help in the mentally healthy population minimally affects the process of becoming depressed. Increasing the rate of influence causes a decrease in the percentage of the depressed population since people know the effects of asking for help during the state of depression and how it affects the recovery process, so they can do it the same way if they enter this state eventually. However, this decrease was not expected to be negligible; the system behavior is practically the same if $p = 0$ and $p = 1$. It is important to study why there is no effect on the depressed population and what can be done to increase it.
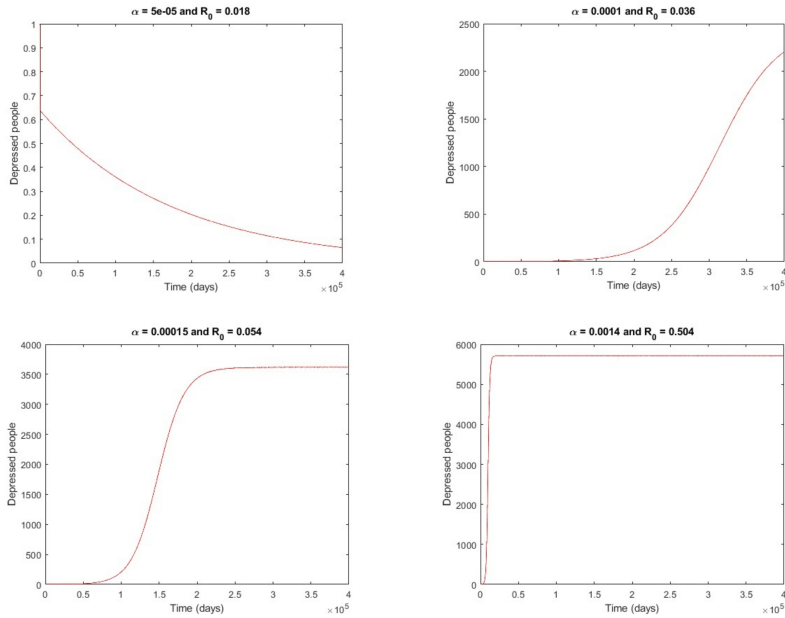
3.2 Varying α

Figure 3: Simulations when α is varied.

Figure 3 shows that increasing the rate of depression also increases the depressed population and R_0, as expected. A rate of $\alpha = 0.0001$ is sufficient for the system to have an endemic equilibrium, even if $R_0 < 1$. Decreasing the current rate by 90% implies a disease-free equilibrium if $R_0 < 1$. As it is a mental health problem, there are inexhaustible reasons why a person enters a state of depression; even a specific cause can not exist, so focusing our efforts on reducing this rate may not be sufficient, although it is necessary.

The focus should be on the depressed population. Providing an efficient support program in which people can achieve good results in their recovery process and educating them about the importance of asking for help must be the priority.
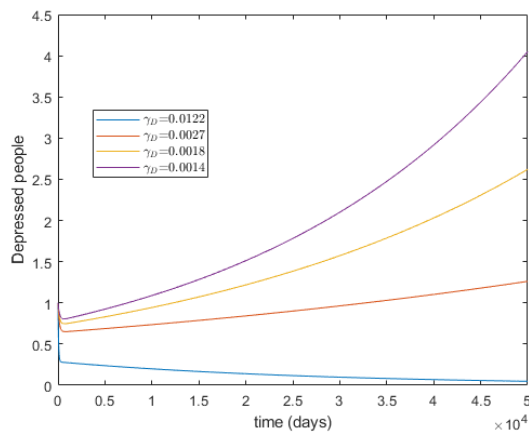
3.3 Varying γ_D

Figure 4: Simulations when γ_D is varied.

Figure 4 establishes that the increase in γ_D implies the reduction of depressed people from the beginning. But why? Perhaps the causes of depression, in general, are insignificant if the γ_D is too high or if there is a good awareness in the population about self-control in a problematic situation. On the other hand, if the γ_D is too low, perhaps the factors to become depressed, facing depression without help for the population may be too difficult because they do not have enough knowledge or self-control to manage their mental state. If we add days by varying the γ_D, the results follow the same path.

According to the results, among many factors that cause depression, analyzing the self-control that motivates people to face depression and recover from it can give us clues about how to educate ourselves to face mental illness if we cannot easily access treatment. Thus, with an education model for self-control when we face depression, γ_D can be increased, which implies a reduction in depressed people.
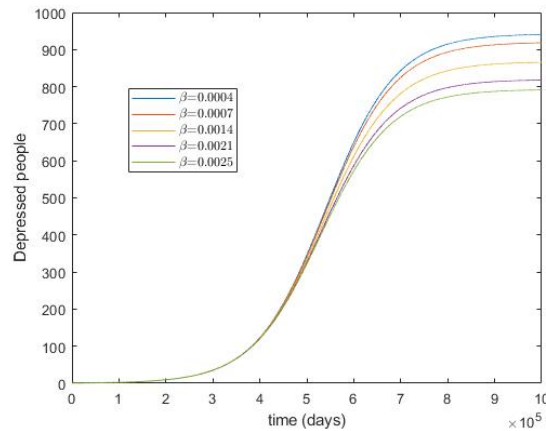
3.4 Varying β

Figure 5: Simulations when β is varied.

Figure 5 establishes that increasing β decreases the estimate of depressed people in the long run. The reason is that with significant investment and the possibility of getting help with long-term mental illness (depression), there will be a reduction in depressed people in the future. Otherwise, if the population is not encouraged to seek help if they have depression that they cannot cope with on their own, in the long run, according to the results, the depressed population will increase. In addition, β can also be a way to alert us to access to seek help for depression.
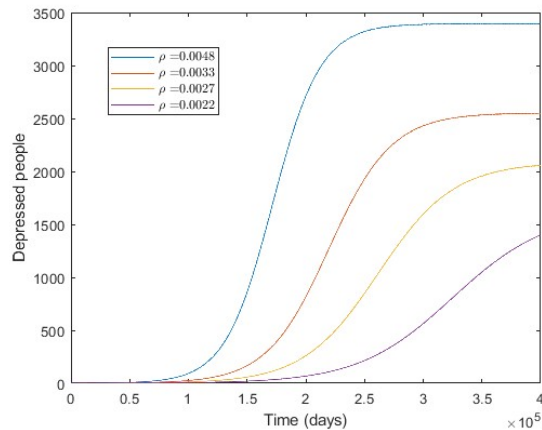
3.5 Varying ρ

Figure 6: Simulations when ρ is varied.

Decreasing the rate of relapsing is essential to decreasing the depressed population. Since it is a mental health disease, recovery does not indicate total immunity; a person may re-enter that state again for various reasons. The graph shows different values for ρ when the recovery period is 7, 10, 12, and 18 months; it indicates that the help-seeking population must remain in the most efficient programs to extend the period as much as possible.

4 Discussion

We propose a mathematical model to analyze the influence of a depressed population that sought help to cope with depression on a population that does not seek help. The model establishes that the influence of the population seeking help on the susceptible population is insignificant, and its results are shown in the long term. Alerting healthy people to the importance of seeking help when in a depressive state does not affect the rate of depression. So we were also interested in what parameters can make a difference in our model? so we decided to analyze the different results by varying specific parameters, such as α, β, γ_D, and ρ, to give an interpretation of what happens when a population suffers from depression.

The simulations of our system indicate to us that the population needs to be aware of identifying symptoms of depression and how to manage it or at least recognize when depression becomes a mental illness that requires treatment. Because if there is awareness of depression, then self-managing depression to recover from it will improve recovery time or the number of people who self-recover from depression. Also, indicate that β, γ_D, and ρ are the parameters that most quickly reduce the percentage of the depressed population. The influence of people who ask for help should focus on the depressed class. This population must understand the importance of psychotherapy, family support, and in some cases, pharmacological treatment, which must be the priority in order to increase β.

Similarly, the results for ρ simulations indicate the importance of improving support programs for depressive people. Comparing programs with different results in patients, where in a normal one, people have a recovery period of almost half a year compared with a much more efficient one that triples that period, shows that we must focus on providing the depressed population with the best resources and improving the current programs or services provided.

In addition, establish a care capacity, in this case of depression, because the parameters will vary their value, exemplifying that if we motivate a large percentage of the depressed population to seek help, then perhaps it would not be possible to serve the entire population.

8

On the other hand, it should be noted that our value parameters are only estimates from other research and generally available data. It would be interesting to analyze a population in a period and establish more precise parameter values, even analyzing a specific population, exemplifying, analyzing the behavior of depression in university students during a period, and establishing better values for the parameters or new parameters as reasons for getting depressed.

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