Mathematical Approach to Study of Complex Behaviour of Students Educational Stress During Covid – 19

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Abstract:-

In this study, a fresh attempt was made to examine dynamic behavior and estimate the ultimate amount of the psychological stress spread among students caused by a rapid breakout of COVID-19. The multicompartmental model makes enquiry about the impact of stress on student education and the significance of stress management to learning successfully. Through qualitative and quantitative studies we show some adequate constrain for the disappearance or spread of psychological stress. To demonstrate theoretical conclusions, numerical simulations are also provided.

***Keywords**:* Covid-19 pandemic, Mathematical model, Physical stress; Mental stress.

1. Introduction

The coronavirus disease 2019 (COVID-19), which appeared in China at the end of 2019, has been declared a pandemic by the World Health Organization (WHO). The rising viral transmission rate, growing number of sick people, and real death rate have wreaked havoc on society, prompting widespread concern and instability. Furthermore, lockdowns, the distribution of false information, and a general lack of understanding have resulted in widespread dread and worry among the general populace. Despite this, in most situations, insufficient resources are advised to mitigate or treat the mental health implications of the COVID-19 pandemic. As a result, this outbreak raises a variety of questions, including if there is a stress/anxiety pandemic tied to this massive disaster. We must recognize that a pandemic is more than simply a medical problem; it also has a social, emotional, and psychological impact on people. Being alone and wearing masks is associated with anxiety, sleep difficulties, panic, tension, and other types of mental illness. Fear of contracting the virus, a lack of treatment, increased mortality associated with the virus, and uncertainty about when the virus will be controlled and a vaccine will be available are the major factors that have been identified as being highly responsible for increasing psychological distress, adjustment, and even more serious mental health problems. Economic loss, interruptions in daily routine, incapacity to engage in social events, and constant media exposure all affect mental health. The situation has become a serious source of concern. People have even committed suicide to be able to escape the horrible realities of mental stress. Because of the pandemic epidemic, many students have developed psychological disorders that are hurting their academics as well as their whole personality.Lockdowns and limited access to schools and colleges in India caused a change in education during the corona virus outbreak. They started by playing video games and viewing films before progression to online lessons. On the other hand, the virus posed both problems and opportunities for students to acclimatize to online learning in schools and colleges during the pandemic corona virus.The educational transition varies from their previous professions in that they were required to attend both home and college classes. 50-60% of students utilize online programs, whereas 80-90% attend classroom sessions. Students spend a lot of time looking at a computer screen. Online education has an impact on their eyes. Small children in play school and primary school should not be exposed to this type of class since they have short attention spans and cannot sit for long amounts of time in front of a blue screen. There are certain drawbacks such as lack of testing: students are graded internally. This might have an impact on their career.These components will influence the life of the child.

Mathematical modeling is usually viewed as the skill of applying mathematics to a real-world situation to better comprehend the problem. As a result, mathematical modeling is inextricably linked to problemsolving. Models are used by engineers to depict the elements of any system. Models are created for produced elements and devices to improve understanding and determine the elements' and devices' operational characteristics. Mathematical models can forecast the progression of infectious illnesses to predict the likely result of an epidemic (including in plants) and assist advice public health and plant health initiatives. Models employ fundamental assumptions or gathered facts, as well as mathematics, to identify parameters for various infectious illnesses and then utilize those parameters to quantify the consequences of various treatments, such as mass vaccination campaigns. The models may assist in choosing which interventions to avoid and which to try, as well as anticipate numerical future development patterns, among other things The goal of this research is to solve the model using numerical approaches.Ronald Rose and William Hammer created the SIR model. Kermack and McKendrinck's theoretical studies on infectious disease models, published between 1927 and 1933, had a significant impact on the development of mathematical epidemiology models [5]. During that period, most of the core theory had been produced.

Mathematical models in epidemiology have a lengthy history, dating back to the seventeenth century. Bernoulli [2] employed a mathematical approach to assessing the efficacy of variolation procedures against smallpox to influence public health policy. The majority of the models are compartmental models, in which the population is separated into groups, and assumptions regarding the rate of transfer from one class to another are established [3, 4]. We use the SEIR models to characterize the virus's propagation and calculate the number of infected and deceased people. There are several variants of the SEIR model and mathematical treatments may be found. The purpose is to calculate the number of infected, recovered, and dead people based on the number of contacts, illness transmission likelihood, incubation time, recovery rate, and fatality rate. We are dealing with a relatively short period, the epidemic illness model forecasts a peak of infected and dead persons each day as a function of time and assumes that births and natural deaths are balanced. The sickness alone causes a decline in population members, as shown by the disease's fatality rate. A forward Euler strategy is used to solve the differential equations. Stress is a state of emotional tension and pressure [1]. Stress is a sort of psychological discomfort. Small quantities of stress can boost athletic performance, motivation, and responsiveness to the environment. Excessive stress, on the other hand, can raise the chance of strokes, heart attacks, ulcers, and mental diseases like depression [2], as well as the aggravation of a pre-existing ailment. Psychological stress can be external and connected to the environment, but it can also be created by internal beliefs that lead an individual to experience anxiety or other unpleasant emotions in response to a circumstance, such as pressure, discomfort, and so on, which they then label as stressful.

In this paper, we have designed a mathematical model for measuring and analyzing the dynamic behavior of psychological stress distribution for students caused by online classes due to the sudden release of COVID-19.

2. Objectives

3. Methods

This model classifies stress into two different classes: (i) Stress due to health issues (physical stress) and, (ii)Stress due to psychological issues (mental stress) including anxiety or other negative emotions, etc. To do so, we consider the SEIR mathematical model by dividing the total population into five --time compartments namely, normal/happy adults $\mathscr{H}(t)$, exposed adults $\mathfrak{E}(t)$, physically stressed SP (t), mentally stressed SM (t) and recovered $\mathfrak{R}(t)$. We also assume that the stress is transmitted to the susceptible population by direct contact with the stressed populations. It is assumed that susceptible individuals after being exposed to the stress can move to any one of the following stressed classes, namely, mentally stressed and physically stressed with different transmission rates. Both types of stressed individuals may recover and after recovery move to the recovered class. However, the rates of recovery may vary from one compartment to another. After recovery students learning quality become very slow.

Keeping the above facts/assumptions in mind, a mathematical model is proposed as follows

$$\frac{d\mathcal{H}}{dt} = \lambda - \mu\mathcal{H} - \beta\mathcal{E}$$

$$\frac{d\mathcal{E}}{dt} = \beta\mathcal{E} - \mu\mathcal{E} - a\alpha_p\mathcal{S}_p - a\alpha_m\mathcal{S}_m$$

$$\frac{d\mathcal{S}_p}{dt} = a\alpha_p\mathcal{S}_p - \mu\mathcal{S}_p - d_p\,\varphi\mathcal{S}_p + C_p\mathcal{S}_p - C_m\mathcal{S}_m - \gamma\mathcal{S}_p \qquad (1)$$

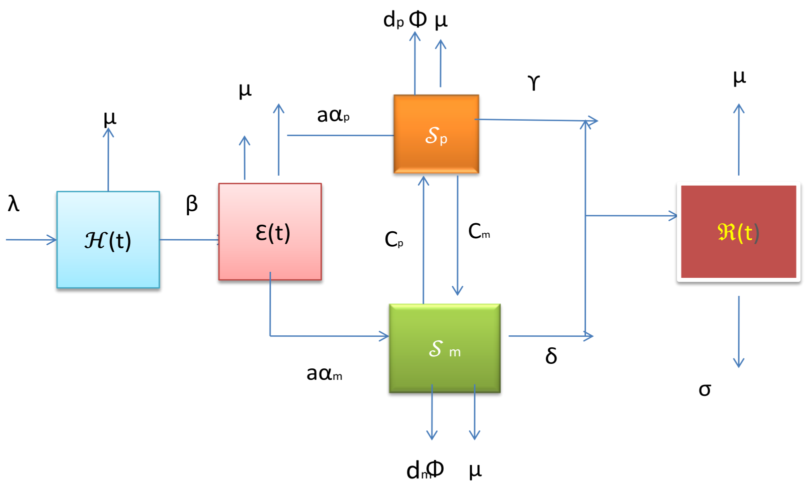
$$\frac{d\mathcal{S}_m}{dt} = a\alpha_m\mathcal{S}_m - \mu\mathcal{S}_m - \delta\mathcal{S}_m - d_m\mathcal{S}_m\varphi + C_m\mathcal{S}_m - C_p\mathcal{S}_p$$

$$\frac{d\Re}{dt} = \gamma\mathcal{S}_p + \delta\mathcal{S}_m - \mu\Re - \sigma\Re$$

Table 1

Parameters	Description of parameters
λ	Online class attended rate
μ	Stress –free rate
1/a	Latent period of stress
α m	Transmission probability of mental stress
α p	Transmission probability of physical stress
Cm	Transmission rate from physical stress to mental stress
Cp	Transmission rate from mental stress to physical stress
Β	Transmission rate of stress
Γ	Recovery rate of physical stress
δ	Recovery rate of mental stress
Φ	depression rate
dp	stress-free rate of physically stressed individuals
dm	stress-free rate of mentally stressed individuals
σ	recovery rate with a deficiency in studies

The proposed model is given below



The remaining parts of the paper are structured as follows. We study the qualitative behavior of the recommended model in the section "Theoretical analysis" which take into account discussing the positivity and boundedness of the system solution (1), the calculation of the basic reproduction number, presence of equilibrium, and their stability analysis. We present numerical simulation results in the section "Numerical Results" to support our obtained conclusions. Finally, in the "Conclusion" section, we provide a conclusion to the study.

Positivity and Boundedness of solution

Theorem: 1 The solutions of model system (1) are bounded.

Proof. Let $\mathcal{N}(t) = \mathcal{H}(t) + \mathcal{E}(t) + \mathcal{S}_p(t) + \mathcal{S}_m(t) + \Re(t)$ *(1.1)*

Then $\frac{d\mathcal{N}}{dt} = \lambda - \mu\mathcal{N} - d_p\Phi\mathcal{S}_p - d_m\Phi\,\mathcal{S}_m$ *(1.2)*

Which gives $\frac{d\mathcal{N}}{dt} \leq \lambda - \mu\mathcal{N}$ *(1.3)*

This implies that $\frac{d\mathcal{N}}{dt}$ is bounded by $\frac{\lambda}{\mu}$

Integrating the inequality (1.3) and using initial conditions, we obtain

$\mathcal{N}(t) \leq \mathcal{N}(0)e^{-\mu(t)} + \frac{\lambda}{\mu}(1 - e^{-\mu(t)})$

As $t \rightarrow \infty$ asymptotically we get $\mathcal{N}(t) \leq \frac{\lambda}{\mu}$.

As a result, all solutions are constrained and independent of the beginning circumstances.

In addition $\lambda > 0, \mu > 0$ we have $\frac{\lambda}{\mu} > 0$ which gives that the invariant set is positive.

Possible equilibria and basic reproduction number

The model system (1) allows two equilibrium points, as disease-free equilibrium (DFE)

$\mathcal{P}^0 = (\mathcal{H}^0, 0,0,0,0) = (\frac{\lambda}{\mu}, 0,0,0,0)$ and endemic equilibrium points(EE) $\mathcal{P}^* = (\mathcal{H}^*, \mathcal{E}^*, \mathcal{S}_p^*, \mathcal{S}_m^* \Re^*)$.

For some epidemic model, the disease-free equilibrium plays an important role as it concludes whether or if the sickness will increase throughout the populace. To find the upheld infectivity of the concept of R_0 is used which is the threshold value of the model(11), and can be determined from the next generation matrix $\mathcal{F}\mathcal{V}^{-1}$ where $\mathcal{F}$ is the transmission matrix which describes the endurance of new infections and $\mathcal{V}$ is the transition matrix which explains the left over transmit terms. The Reproduction number R_0 is predetermined by the spectral radius $(\mathcal{F}\,\mathcal{V}^{-1)}$. After finding the next generation matrix, the calculated reproduction number at DFE for the system (1) is given by

$$R_0 = \frac{(a\alpha_p + C_p)(a\alpha_m + C_m)[(\mu+\gamma+d_p\varphi)(\mu+\delta+d_m\varphi) - C_pC_m]}{[(\mu+\gamma+d_p\phi)(\mu+\delta+d_m\varphi) + C_pC_m]}$$

Existence of endemic equilibrium

The DEF point is unstable when $R_0>1$. The considered model has DFE at $(\frac{\lambda}{\mu}, 0,0,0,0)$.

The existence of DFE $\mathcal{P}^0 = (\mathcal{H}^0, 0,0,0,0)$ is true.

Next we study the EE $\mathcal{P}^*= (\mathcal{H}^*, \mathcal{E}^*, \mathcal{S}_p^*, \mathcal{S}_m^* \mathfrak{R}^*)$.

Theorem: 2 The endemic equilibrium point $\mathcal{P}^*= (\mathcal{H}^*, \mathcal{E}^*, \mathcal{S}_p^*, \mathcal{S}_m^* \mathfrak{R}^*)$ exist if $R_0 > 1$.

Proof. The endemic equilibrium for model system (1) is $\mathcal{P}^*= (\mathcal{H}^*, \mathcal{E}^*, \mathcal{S}_p^*, \mathcal{S}_m^* \mathfrak{R}^*)$,
Where

$$\mathcal{H}^* = \frac{\lambda - \beta E^*}{\mu}$$

$$E^* = \frac{a\alpha_p \mathcal{S}_p^* + a\alpha_m \mathcal{S}_m^*}{\beta - \mu}$$

$$\mathcal{S}_p^* = \frac{(a\alpha_m + C_m) - (\mu + \delta + d_m\varphi)}{\left((a\alpha_p + C_p) - (\mu + \gamma + d_p\varphi)\right)\left((a\alpha_m + C_m) - (\mu + \delta + d_m\varphi)\right) - C_m C_p}$$

$$\mathcal{S}_m^* = \frac{(a\alpha_p + C_p) - (\mu + \gamma + d_p\varphi)}{\left((a\alpha_p + C_p) - (\mu + \gamma + d_p\varphi)\right)\left((a\alpha_m + C_m) - (\mu + \delta + d_m\varphi)\right) - C_m C_p}$$

$$\mathfrak{R}^* = \frac{\gamma \mathcal{S}_p^*}{\mu + \sigma} + \frac{\delta \mathcal{S}_m^*}{\mu + \sigma}$$

Since $\mathcal{P}^*$ is positive only if $R_0 > 1$.

We can easily observe that there is an equilibrium of endemic if $R_0 < 1$.

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Stability analysis

Theorem: 3 The DFE is locally asymptotically stable provided the following hold;

$A_1 > 0$, $A_2 > 0$, $A_1A_2 - A_3 > 0$ (2)

where A_i's are defined as follows

$A_0 = 0$, $A_1 = -(P+Q+R)$, $A_2 = PQ+QR+RP - C_p C_m$, $A_3 = -PQR + RC_p C_m$

Otherwise unstable and P, Q, R are defined below

$P = a\alpha_p + C_p - \mu - \gamma - d_p\varphi$

$Q = a\alpha_m + C_m - \mu - \delta - d_m\varphi$

$R = \beta - \mu$

Proof.

The CE of system (1) correlated to $\mathcal{P}^0$ is given by

$$\begin{vmatrix} -\mu-\lambda & -\beta & 0 & 0 & 0 \\ 0 & \beta-\mu-\lambda & -a\alpha_p & -a\alpha_m & 0 \\ 0 & 0 & P-\lambda & -C_m & 0 \\ 0 & 0 & -C_p & Q-\lambda & 0 \\ 0 & 0 & \gamma & \delta & -[\mu+\sigma]-\lambda \end{vmatrix} = 0$$

Expanding the above determinant, we get the following CE;

$$(-\mu-\lambda)(-(\mu+\sigma)-\lambda)(A_0\lambda^3 + A_1\lambda^2 + A_2\lambda + A_3) = 0$$

The above equation has two roots which are less than 0. The remaining terms are the cubic polynomial.

Applying the Routh Hurwitz criterion the DFE $\mathcal{P}^0$ is locally asymptotically stable provided (2) holds

Hence the DFE is locally asymptotically stable.

In this section, we support the conclusions from our analytical work using numerical simulation. In our illustration, we predict that 80% of the students taking part will be satisfied while only 20% will be dissatisfied. Individuals embody the exposed class. To the finest of the author's intelligence, no journalism research on the dynamic behavior of psychological stress quantifies transition processes from one class to another

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We can see that when we increase (or reduce) the value of, the rate of recuperation of physically/mentally strained populations increases (or decreases). As a result, the distribution of stress in the population is significantly influenced by factors. As one would think, a faster recovery rate will result in a lower rate of stress spread. In practice, we can raise the values of parameters by exercise, yoga, meditation, participation in various home tasks (throughout the lockdown time), hobbies, music listening, and spending less on unneeded actions are all examples of things to engage in. Nowadays, digital media is also a big assist in reducing stress.

4. Results

Numerical solutions and applications

To support our analytical findings, we do a numerical simulation in this part. In our situation, we estimate that, of the total population concerned, 90% will have content pupils and 10% People represent the exposed class. To the best of the author's familiarities, no literature study for the dynamic behavior of mental strain quantifies the mechanisms for moving between classes. Therefore, we selected values for the majority of the parameters. We can observe from the numerical simulations shown in Fig.1 that as γ and δ rises, the rate of recovery also rises. On the other hand, the student's stress is recovering more slowly with smaller values of γ and δ.

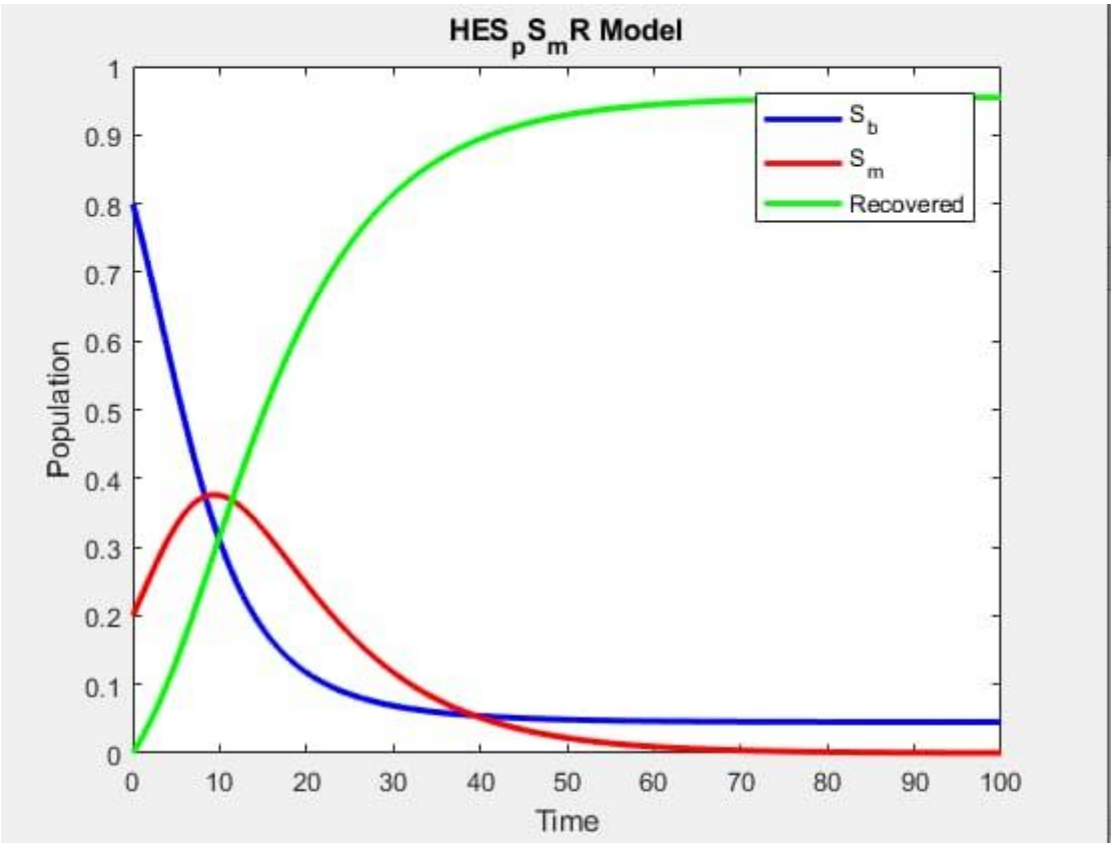

Fig 1: Graphical representation of physically ,mentally strained and recovered students

5. Discussion

We have been practicing hobbies such as Yoga, meditation, and physical exercises indoors to preserve themselves healthy, fit, and stress-free, according to the current study's finding. Furthermore, people have been involved in a variety of activities that may keep them occupied, and there have been countless interior choices such as catering, crafts, comprehension, farming, indoor gaming, or being digitally bilateral. This keeps them active and allows them to address any pre-existing issues that may cause stress and as a result, harm their psychological well-being.

These activities may not be a long-term answer to stress and ensuring people's well-being, but they may serve as a short period of time approach to keep oneself stable in situations when tension can be harmful to anyone's health. As a result, research in this area is novel and uncharted. It is suggested that the researchers conduct more research and give some remedies to these sorts of stressful situations.

Stress may induce panic-like situations, bad sensations, and mood fluctuations that not only impair one's well-being but also spread to their public gathering. If not addressed, it can lead to famish social interactions as a person becomes lonely, thinks a lot, and responds in ways that are not expected of their peers or social gathering. Deeper exploration of the connections between diverse coping mechanism and pressures may be the focus of future research. Additional, study is required to determine how the epidemic may affect student's welfare and mental health following COVID-19.It's possible that the pandemic's effects on students won't fade even when the COVID-19 epidemic is over.

We developed and tested a mathematical model to investigate the active behavior of stress of the students during online classes caused by the unexpected outbreak of COVID-19 in India. The distribution of stress in the student populace has been classified into five phases (i)Happy or normal students (ii)Exposed students (iii)Mentally strained students (iv)Physically stressed students and (v) Recovered. In adding to model construction, the fundamental reproduction number (R_0) and the local stabilities of various equilibriums are investigated. In addition to the theoretical research, an empirical analysis was performed to determine the influence of psychological strain on the bodily or intellectual health of individuals in India in the present context. In addition to model construction, the fundamental reproduction number (R_0) and the local stabilities of various equilibriums are investigated. In addition to the theoretical research, a numerical analysis was performed to determine the influence of psychological strain on the physical or mental health of individual students in India in the current context. Starting with the conclusion, the numerical and theoretical study revealed that perceived strain hurts the psychological welfare of the student, which is a common occurrence. Student's ability to lead and keep their psychological well-being can be hampered by discovered stress. This can lead to episodic stress, acute stress, and other types of stress in students, which can direct to negative thoughts that expose them to psychological issues and disrupt their daily lives. Students appear to have taken proactive and aggressive measures to avoid being exposed to such situations.

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