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A System Dynamics Approach for Analyzing the Behavior and controlling Widespread illness in Iran

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ABSTRACT

To assess the influence of vaccination on widespread illness Peak Infection Rates, Widespread Illness Death Rates and the performance of public health authority control efforts, this research employs a System Dynamics methodology to examine the behavior of disease over time. The ability to classify populations into distinct subgroups enables a clearer understanding of how diseases spread, as well as the effect of intervention. A full mathematical model was created with seven population categories ("Vulnerable", "Suspected", "Infected", "Hospitalized", "Quarantined", "Recovered" and "Deceased") to simulate widespread illnesses under the following scenarios: Current Conditions; 40 percent Initial Vaccination Rate; and 30 percent Reduction in Vulnerability via Restrictions. Additionally, the simulation incorporated quarantine and intervention classes to evaluate the effect of these methods on transmission. Results from the simulations show that lower vaccination rates (40 percent vs. 62.5 percent) will result in an 84.9 percent increase in patients and a 87.8 percent increase in deaths. These findings illustrate the importance of both high vaccination rates and reductions in vulnerability in limiting the severity of the pandemic. This study provides significant contributions toward identifying a behavior pattern for the spread of and control of Widespread Illnesses, especially as they relate to developing countries. Finally, it offers useful information about the effectiveness of vaccinations and other intervention strategies in reducing the impacts of subsequent waves of pandemics.

1. Introduction

Many different aspects of a person's normal day-to-day life have been negatively impacted by the occurrence of both epidemics and pandemics throughout all of human history[1]. Following a major disaster, such as a pandemic, it usually takes years for the quality of life to improve, thus leading to the development of new mental models and ways of doing business. The 1918 Spanish influenza pandemic led to a massive global crisis.

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It was first identified in December 2019 [2] in the Chinese city of Wuhan (Hubei province) and then became an infectious disease that spread across more than 180 countries around the world. On March 11, 2020, the World Health Organization designated the infectious disease as a pandemic because it had now spread into many parts of the world. Although many countries claimed they had made great strides toward the development of treatments, there is currently no vaccine or treatment for this disease [3] and studies indicate that many patients who died from this disease also suffered from underlying diseases such as high blood pressure, diabetes, heart disease, poor vascular health, and a compromised immune system [4] , [5].

During the early phases of the pandemic, some countries have been successful in limiting the spread of infectious disease (Anderson et al., 2020). To contain the epidemic, China utilized a variety of measures, including quarantines, social distancing, and isolating infected populations; these measures assisted in controlling the spread of the epidemic [6]. The health, education, security, and transportation sectors in Colombia took actions to limit the spread of the virus by following guidelines issued by the WHO and other international organizations [7]. The measures used to limit the spread of the epidemic resulted in a flat epidemic curve and reduced the risk of the spread of the epidemic, and thereby limited the impact of the epidemic. The measures included:

- The health system was able to optimize vaccination and treatment time.
- Measures to prevent widespread contamination within the educational system were implemented.
- A monitoring system was established to protect against the potential collapse of the economy should an economic recession occur.

To increase awareness among citizens about the need for health related prevention measures, a citizen readiness phase was initiated and recognized the overall public's vulnerability to the adverse effects of disasters of this type [8]. The initial cases of the disease were effectively prevented from entering or immediately identified through strict controls of airport entrances. The confirmation of the first case on Friday, March 6 marked the transition to the containment phase to address the disease. At that point, while measures such as encouraging social distancing, cancelling events, and closing schools and universities had already begun, the country rapidly moved into the risk reduction phase, or social contact phase, as a result of the lack of social distancing by many individuals and the difficulty in identifying the source of each case. With airports closed, social distancing enforced, enhanced healthcare measures, increased biodefense and security protocols, and enhanced quarantine orders (including traffic restrictions and penalties for violators who endangered public health) further measures were enacted. An emphasis was placed on individuals aged 60 and older, and children, during this time.

Recommendations put forward by the government to fight the disease include: a) use of immigration application processes and counseling regarding disease, b) use of dedicated aircraft to transport high risk populations such as healthcare and hotel workers, c) compliance with health directives and encouragement of self care. The government determined that use of biosecurity resources and security protocols were not required.

A dynamic model was developed to evaluate the public health and safety measures implemented by authorities to prevent the spread of the disease since there is no vaccine or treatment [9], [10]. Qualitative assessments of outcomes rather than actual quantitative measurement of performance metrics and evaluations of other epidemic capacity or dynamics, as evaluated by reputable international organizations, were utilized in developing the model. System dynamics modeling was employed to generate a variety of scenarios using threshold values for each criterion's implementation. These scenarios enabled the evaluation of alternative measures to reduce the spread of the virus, and potentially stop the spread of the virus, and project the timing of their implementation.

Iran, a country with an estimated population of 84 million, reported its first case of Widespread illness on February 19, 2021 [11], [12], [13]. The spread of Widespread illness in Iran occurred in three distinct waves, with the first two waves exhibiting exponential growth in close proximity to one another, and the third wave exhibiting strong exponential growth following a period of relative stability in the disease (Figs. 1–3). Although the rate of growth appears to be slowing, the data indicates that a fourth wave may be beginning. Furthermore, in alignment with the data, the mortality rate has escalated simultaneously with the peaks of the Widespread illness at each stage. Although recovery cases represent a greater proportion of the total number of cases and closely approximate the rate of infection cases, the third prominent wave demonstrated a greater infection rate than the recovery rate, resulting in a substantial increase in the death rate during this interval.

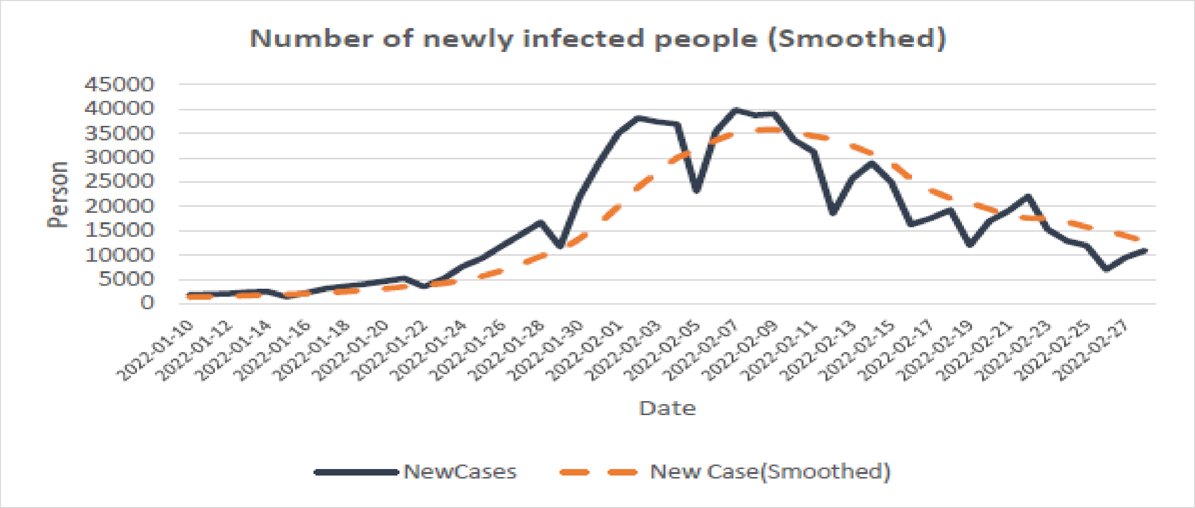


Figure 1: The number of newly infected people trend

The graph below shows the total number of infected people during the sixth wave.

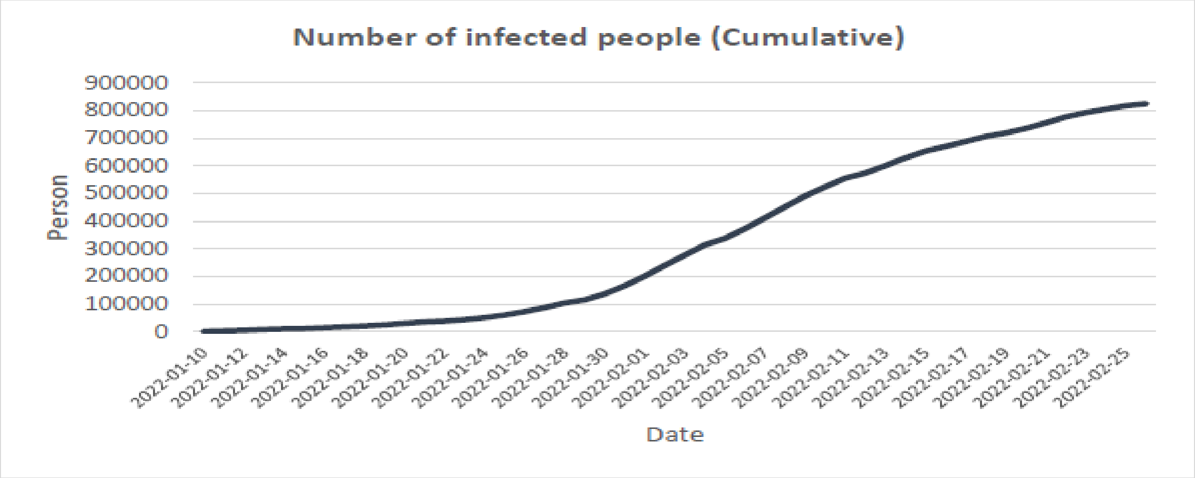


Figure 2: The number of total people infected

The cumulative number of deaths is also shown in the following diagram.

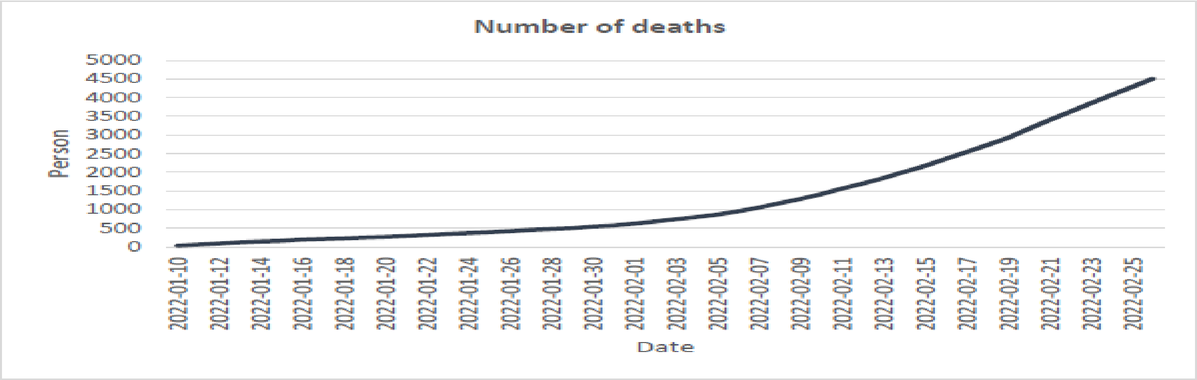


Figure 3: The total number of deaths

Although the time interval was broken down into smaller segments, the variability in Widespread illness prevalence throughout Iran led to different types of interventions being taken in each of the time segments. Widespread illness has been affected by different interventions and measures adopted in Iran and other parts of the world. This study therefore aims to evaluate the spread of the virus and the corresponding interventions taken when the virus reached its maximum rate of dissemination (January 10th, 2022). Approximately 52.5 million people in Iran were vaccinated against the Omicron variant at least twice during the time when the virus had reached its maximum rate of dissemination. As depicted in the above figure, the number of new cases reported per day are indicated. Therefore, this paper will introduce a mathematical model that includes a vaccination component and possible interventions adopted by governments including lockdowns, social distance media campaigns, and improved public hygiene to potentially limit the spread of the virus. Mathematical models are becoming increasingly important for explaining the epidemiology and propagation of infectious disease epidemics. The name "mathematical modelling" suggests that mathematical models serve as tools for representing and depicting a wide variety of actual-world problems using the mathematical language.
To analyze and control common infectious diseases, a great deal of research has been carried out on the application of system dynamics models. The primary focus of this study is on typical scenarios, such as widespread illness, vaccine effects, and government reactions. The model used in this study, which categorizes people into four groups: susceptible, infected, recovered, and dead, has been widely utilized in previous research; consequently, this study is relatively less distinct than previous ones. To improve the academic value of this work, it is necessary to clearly state and demonstrate a well-defined research requirement. The current study does not clearly define the methodological, theoretical, or contextual voids that it intends to fill. An obvious area of research deficit may involve investigating the influence of multiple sociocultural variables on public compliance, examining the limitations of the healthcare infrastructure in certain geographic locations, incorporating behavioral or economic variables that earlier

models overlooked, or investigating the compatibility of vaccination methods with culturally relevant public health policies in Iran and similar developing countries. By highlighting and clarifying these unexplored or insufficiently explored areas, the manuscript will become much more relevant and unique, and as a result, a much more appealing addition to the existing body of knowledge.
The purpose of this paper is to determine the extent to which vaccination and government intervention strategies contribute to the management and elimination of the widespread illnesses virus. The primary objective of the study is to identify the relative contributions of vaccination and government intervention strategies.
The research question of this study concerns understanding the behavior of widespread illnesses in Iran and how this model can help inform responses to future generations of the virus.

The manuscript lacks innovative methodologies. A large amount of research has been completed regarding the application of system dynamics to model the spread and control of widespread illnesses. This study mainly restates established modeling frameworks, population segmentation methodologies, and intervention scenarios that have been studied extensively by many researchers. This study fails to produce any novel theoretical contributions, significant methodological advancements, or distinctive perspectives that go beyond existing literature to provide novel information about the Iranian context. The authors must explain novel aspects, such as previously unexamined socio-economic variables, distinct cultural or behavioral characteristics, or innovative hybrid simulation techniques to distinguish the study from prior studies and to highlight the study's original research contributions to advance the scientific community's understanding of the behavior of widespread illnesses in Iran through a comprehensive literature review. The use of system dynamics has revealed the occurrence pattern of widespread illnesses in Iran and enables decision makers to develop strategies for dealing with this disease as well as similar diseases that could emerge in Iran or other developing countries. Furthermore, the application of a scenario-based strategy was employed to demonstrate applicable strategies for managing diseases under specific conditions.
Our study contributes to the system dynamics and public health decision-support literature by applying an integrated, scenario-based modeling framework that explicitly links vaccination coverage, mobility-reducing policy interventions, and pressure on the healthcare system within a single feedback loop. Although the basic modeling principles are rooted in the traditional system dynamics theory, the novelty of this work lies in its behavioral interpretation of policy interventions as part of comparative scenario analysis to find vaccine thresholds and timing-sensitive levers for developing country contexts that are of particular interest for the management of a pandemic.
The paper consists of five sections. Section One provides an overview of the topic and presents the gaps

in the existing research as well as the contributions of the study. Section Two provides an extensive review of prior studies to reveal the existing research gaps. The methodology of the study is explained in detail in Section Three. The explanation of data analysis is detailed in Section Four. Section Five contains the discussion of the results and the conclusion of the study is presented in the final section of the paper.

2. Literature Review

Wu et al. [14]were able to estimate the basic reproduction number R0 as an unchanging quantity over time within the initial research regarding the transient transmission of COVID-19. Models have been used to measure the reproductive ratio and the epidemic course and to determine how to control the spread of the virus and alleviate pressure on the health care system. Liu et al.[15]assessed existing models and estimated the reproduction number (R0) of the prevailing infections in Canada. Tuite et al. [16]studied the effectiveness of non-pharmacological methods of controlling the spread of the prevailing infections in Canada and lessening the burden placed on the health care system. Their results indicate that unless there is significant physical distancing or some other measures in conjunction with moderate physical distancing, the hospitals will be overwhelmed by the use of intensive care unit (ICU) resources. Additionally, their results show that using variable degrees of physical distancing dynamically can allow for the maintenance of the capacity of the health system and provide intermittent psychological and economic relief. Bordehore et al. [17]developed a custom-made gaming model (utilizing STELLA (R) software from Isee Systems) that is flexible enough to be applied to various areas and user preferences. This model allows the users to evaluate multiple possible scenarios to understand the behavior of COVID dynamics.

Anderson et al. [18]studied the effects of national mitigation efforts on the trend of widespread illness. The authors concluded that although there are many unknowns associated with COVID-19, the predictions based on modeling can assist policymakers in making informed decisions. The authors highlight the need for authorities to consider a range of scenarios that include the tracking of all infected people throughout the country, providing a means to intervene quickly once infection rates increase. Authorities should have a thorough comprehension of the ways in which infections occur when they select and compare simulation scenarios. Social distancing and quarantine measures may be impeded by cultural issues and economic concerns associated with the implementation of these measures. In fact, the authors emphasized that the public's response to prevention recommendations is just as important as the government's response and require strategies to reduce the negative economic effects of isolation measures, particularly on employment. An efficient communication system is also necessary for the success of these actions. Using a stochastic model of the spread of the disease and reported cases of the disease, Kucharski et al. [19]developed a mathematical model to describe the initial spread of COVID-19.

Understanding the dynamics of system behavior during outbreaks of infectious diseases is crucial for developing effective plans and managing the outbreaks of these diseases. Therefore, it is essential to understand the behavior of outbreaks of infectious diseases so that health systems, equipment, and treatment staff are prepared for the possibility of an outbreak. Preparedness of treatment systems and ability to respond appropriately are both important in reducing the detrimental consequences of disease outbreaks. A fundamental basis for preparedness of treatment systems is accurate understanding of the behavior of disease outbreaks. Shortcomings can develop even in situations where the health and treatment systems are adequate if the understanding of the behavior of disease outbreaks is inadequate [8].

Advances in recent years in mathematical modeling and simulation have greatly enhanced the understanding of the behavior of disease outbreaks, resulting in the development of successful strategies for managing disease outbreaks.

In many research contexts, the consideration of the incorporation of population isolation into epidemic models and the differentiation of patient quarantine and population isolation have received relatively little attention. To investigate the diffusion of widespread illnesses viruses, this study employs a model developed using system dynamics, tailored to Iran's present situation. The model includes three states of health; identifying and isolating patients; and the effect of education and disseminating information, as calibrated using data currently available [20][21].

Modeling employing system dynamics was used as a technique to evaluate health complexities and to forecast system behavior. While many models are based upon SIR models, some diseases appear after a latency period during which patients are infected prior to manifestation of symptoms, and treatment occurs subsequent to the manifestation of symptoms. Transmission of the disease is infrequent and the disease is minimally contagious during the latency period.

The authors contend that such closures can stress health systems due to increased absences. Table 1 outlines the previous studies.

Table 1. Previous studies

Author/s	Method/s
Wu, Leung, and Leung (2020)	susceptible-exposed-infectious-recovered (SEIR) model
Liu et al. (2020)	age-structured compartmental mode
Bordehore et al. (2020)	game model

Anderson et al. (2020)	model-based forecasts
This research	System dynamics and simulation

3. Methodology

3.1. Procedure of research

Drawing upon Sterman's work on business dynamics [22] and other relevant studies, this study used the following four sequential steps to build a dynamic systems model of a pandemic in a wave format:

Step 1: Define the Specific Problem Statement and Identify the System Boundaries: The first step is to define the specific problem statement (and) to identify all aspects of the model that are present in the literature and to consult with experts. Through these two methods, we can clearly define the boundaries of our model.

Step 2: Develop the Cause-and-Effect Diagram: In the second step, we develop a cause-and-effect diagram (diagram) using the causes and effects identified in the previous step. Using the causes and effects, we create the cause-effect model. We label the loops and feedback in the diagram as either positive (+) or negative (-), and assign labels to the corresponding arcs.

Step 3: Build the Stock and Flow Diagram and Develop the Mathematics that Relates the Variables: In the third step, we develop the stock and flow diagram (diagram) using the cause-effect model developed in the previous step. We determine the stock and flow variables using relationship logic, available data, and expert input once we have developed the appropriate cause-and-effect model. We use the above three inputs to develop the mathematics that relates the variables in our model.

Step 4: Run the Model: In the fourth step, we run the model using a specialized simulation program (e.g., Vensim PLE) for simulating systems models.

The final step: Execute the Scenarios and Evaluate the Results: Finally, we execute the scenarios defined in Step 1 of the model and evaluate the results in detail.

Figure 4 illustrates the research process.

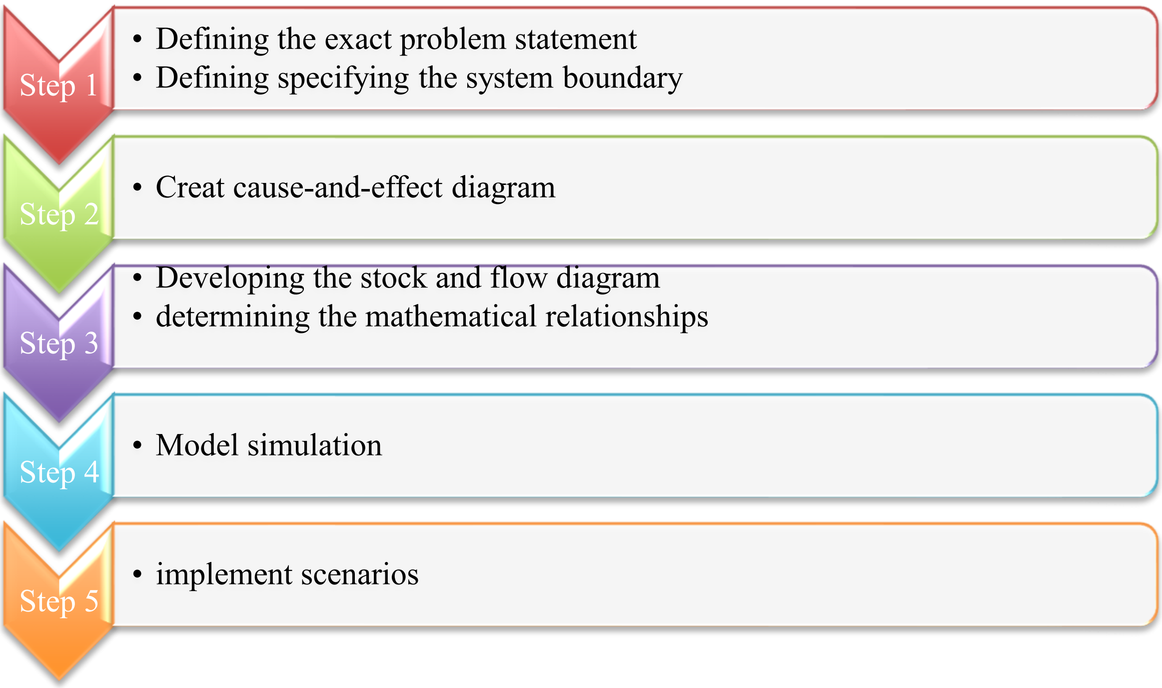


Figure 4. Research procedure

3.2. Dynamic Hypothesis Development

The dynamic hypothesis describes the internal factors that contribute to the creation of the problem, by describing them. The process for developing a Model Boundary Diagram is done by identifying the endogenous and exogenous variables relevant to the problem. In addition, the relationships among the sub-systems are described in detail using a detailed pictorial representation. The rapid spread of the widespread disease increases the risk of exposure to other people, and therefore increases the mortality rate. The method used to model the data for this project was based on a model developed by Kucharski et al. [19]. The method used is consistent with the method described above. The connections between physical movement, hospitalization of patients based on their level of seriousness, the transfer of information, and the need for government to take action to limit contact between sick people and those at risk, were all integrated into the model. These factors were then quantified through the use of the "pressure to measure" variable. Through estimating the expected peak of the outbreak, this model will enable governments to make decisions in a timely manner as to how they manage virus outbreaks; specifically, taking measures to prevent the collapse of the health care delivery systems and possibly provide sufficient time to expand the capacity of the system.

4. Data analysis

4.1. Conceptual Diagram

The causal relationships between the interaction of infected contacts and interactive infections are due to the reinforcing feedback loops of R1 and R2; the higher rate of interactions with infected individuals results in increased infection rates, which in turn causes an increase in the number of infected individuals. The dependency of contact rates on infection rates increases the number of interactions with infected individuals, creating a self-sustaining feedback mechanism that creates a cycle of illness among many individuals.

The harmful feedback loop that begins with the two positive feedback mechanisms of R1 and R2 results in rapid spread of the disease. As the unbridled individual ignoring recent measures and the virus outbreak accelerates the spread of this undesirable feedback loop, the number of infections grows exponentially. To counteract the influence of the dominant positive feedback loop, the authors identified and developed compensatory feedback loops. In this study, if the pressure for implementing indicators becomes too high and a certain threshold is reached, an additional indicator is implemented, along with an additional compensatory loop (B5), thereby lessening the dominance of the cycle and lessening the problems in the affected system. These indicators include warning signs, closing schools, remote work, and restricting travel.

An example of causal loop diagrams illustrating the automatic feedback loops that occur after a widespread illness includes several additional negative feedback mechanisms. A time delay occurs for individuals to exit the cycle of widespread illnesses (B7 and B8) as the number of infected individuals continues to grow. When the number of patients grows, the number of patients being hospitalized also grows, and when the number of patients being hospitalized grows, the number of recovered patients also grows at a later time, therefore decreasing the number of patients (B13 and B14). An increase in the number of hospitalized patients (B11 and B12) will result in an increase in the number of deaths, and as the number of deaths increases, the number of hospitalized patients will also increase. Figure 5 shows the Cause and Effect Diagram of the widespread illnesses Disease Outbreak Model.

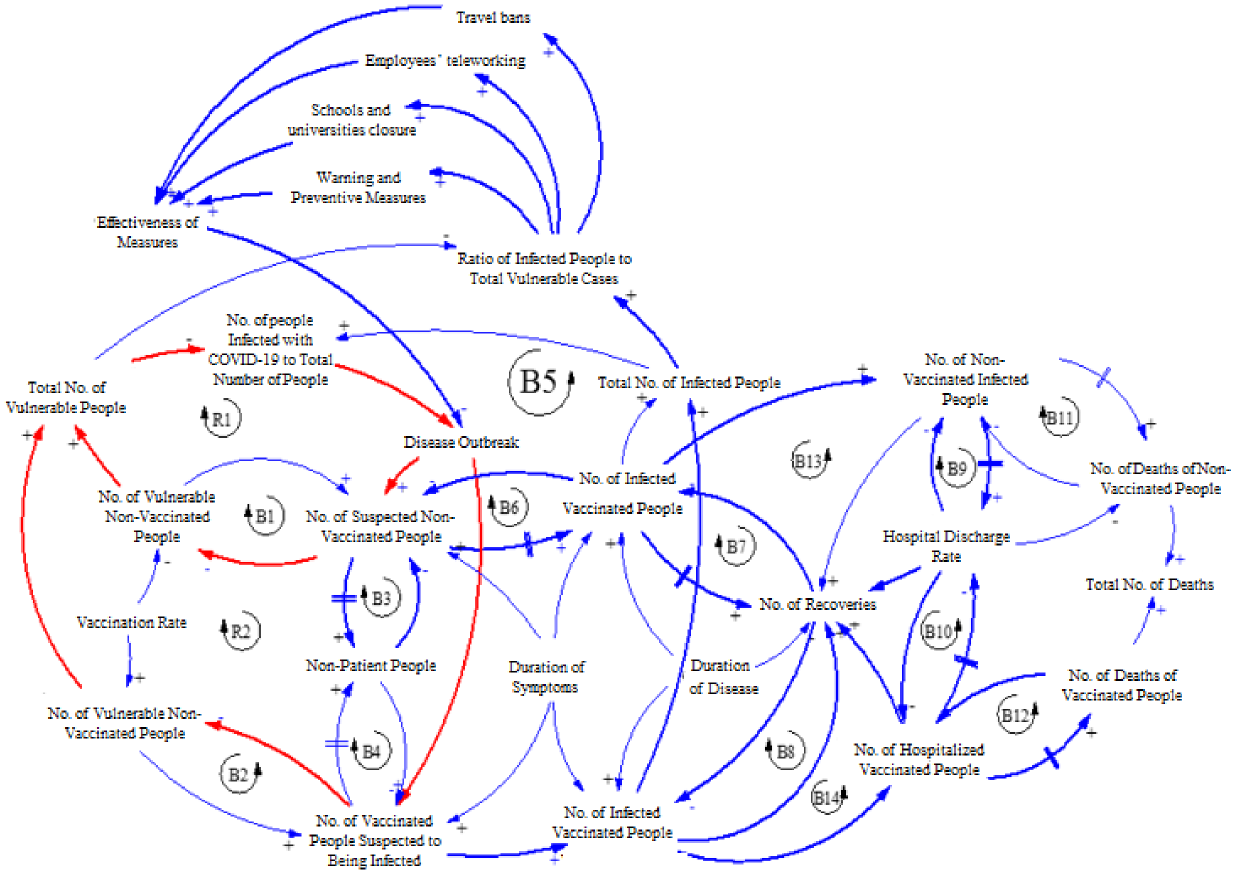


Figure 5: Cause and Effect Diagram of the Widespread illness Disease Outbreak Model

4.2. The Model Variables

to make this article about stocks and flows read like an article from a human perspective. You should NOT modify the content, but rather reword it as you see fit. You should also ensure that all facts and dates remain intact, however you may adjust wording as needed. Do not answer the question, simply reword the content below.

START_TEXT

Stock-type variables track the cumulative count of people exposed to the possibility of becoming ill because of the nature of their work or the fact that they live in a specific area of the country. As the time elapses, people who become ill, die, or recover reduce the pool of people that could potentially contract the disease. This pool can be estimated by taking the initial amount of infected individuals (approximately 10% of the population) and using them to establish the baseline for future projections. We track the rate at which people in the general public encounter other people who are vulnerable to contracting the disease. In the beginning, this rate is very low due to the limited opportunity for individuals living in small communities to come into contact with others that have contracted the disease. However, as the population grows and spreads out, so does the interaction rate and ultimately reaches its maximum potential.

In the next section, we will further discuss how the lack of protection rate has been integrated into our model after the individual becomes a patient.We determine the number of people that have possibly contracted the disease based on the percentage of people that are currently healthy but fall ill and then multiply this by the number of people that are considered to be in the "at risk" category. We use several different factors in calculating this rate including the contact rate of the virus, the potential for the virus to spread in a given area of the community, and the ratio of people that have fallen ill to the total population. We sum the number of people that have received vaccinations with the number of people that have not received vaccines to arrive at the total number of possible cases. Recovered patients are excluded when determining the cumulative count of infected individuals. Instead, their count is determined by the total number of people that were diagnosed with the disease in each time frame.The total number of patients that have successfully recovered is equivalent to the total number of people that have successfully recovered.Adhering to the following criteria will help to limit the extent of the outbreak caused by the widespread illness:

1.To implement a ban on travel

2.To facilitate working from home for employees

3.To temporarily close schools and colleges

4.To issue warning and take preventative measures

When there is an outbreak of widespread illness, only 40% of people said they would seek medical attention immediately if they demonstrated signs/symptoms of the disease while traveling. Over 60% of the respondents agreed that limiting night-time traffic in the city was acceptable, and that restricting travel in red and orange zones to non-locals, closing certain trades and businesses, and imposing penalties/fines on those that violate the rules, were acceptable actions to take. Additionally, over 60% of the respondents agreed that businesses that violate the restrictions should be required to display some type of marker to indicate they are violating the restrictions. Lastly, 76% of the respondents felt that event coordinators should be held accountable for the consequences of holding large-scale events when the community is under restriction.

Following the cause-and-effect diagram, we create the stock and flow diagram.

4.3. Flow Diagram

In the following illustration (model stock and flow diagram) two ages were considered for the Iranian population. Figure 1 illustrates how populations move throughout a sequence of states. Based on how infectious the virus is and based on the contagiousness, people that are believed to be infected are directed to either a vaccinated population or those that have been vaccinated twice. People that begin experiencing symptoms are then moved to the infected population. A person that has developed an infection will either get better and no longer be in the infected population or require hospitalization. If they survive hospitalization they will be removed from the infected population and placed into the deceased population; if they do not survive hospitalization they will also be removed from the infected population and placed into the deceased population.
Figure 6 illustrates the stock and flow diagrams shown above in Figure 1. These models of stock and flow are depicted mathematically using the equations provided in Table 2.

Table2- Mathematical Relations of the Stock and Flow Diagram

Relation 1	$exposed = \int (get\ exposed - no\ symptoms - show\ symptoms)$
Relation 2	$infected = \int (show\ symptoms - hospitalization - recovered\ in\ quarentine)$
Relation 3	$hospitalized = \int (hospitalization - dying - recovering\ hospital$
Relation 4	$get\ exposed = vaccinated\ people\ (Healthy) \times infectivity$
Relation 5	$infectivity = contacts\ with\ infected \times effect\ of\ vaccination$
Relation 6	$contacts\ with\ infected = (1 - accumuled\ effectivness) \times \frac{contacts}{contacts + susceptible\ people}$
Relation 7	$Contacts = infected + infected\ (VP)$

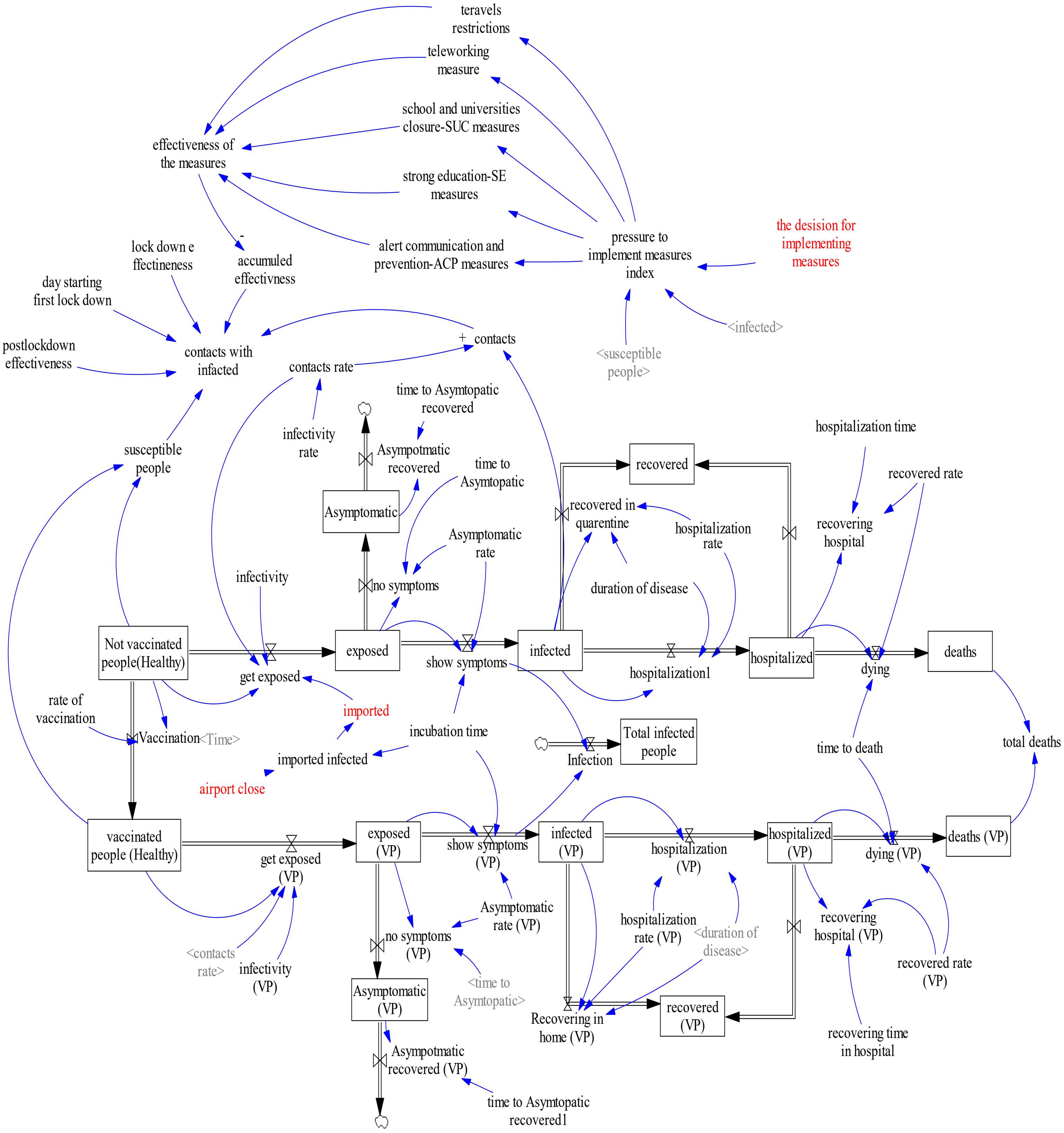


Figure 6: The Stock and Flow Diagram of the Widespread illness   Disease Outbreak

Following is Table 3 showing the initial values of the stock variables:

Table 3- Initial Values of the Stock Variables

Row	Stock variable	Initial value	Description
1	Not vaccinated people (Healthy)	625,149,3	Two variables related to people placed in the vulnerable group due to working conditions
2	vaccinated people (Healthy)	375,249,5	
3	exposed	0	The initial value of the stock variables at the beginning of WIDESPREAD ILLNESS 6th wave is considered zero.
4	exposed (VP)	0	
5	Asymptomatic	0	
6	Asymptomatic (VP)	0	
7	infected	0	
8	infected (VP)	0	
9	hospitalized	0	
10	hospitalized (VP)	0	
11	Deaths	0	
12	deaths (VP)	0	

Below is Table 4 showing the parameters considered in the above model.

Table 4- The Parameters of the Stock Variables

Row	Parameter	Value	Unit
1	Initial rate of vaccination	0.625	Dmnl
2	Asymptomatic rate	0.40	1/day
3	Duration of disease	5	Day
4	Effect of vaccination	0.05	1/day
5	Final time	100	Day
6	Hospitalization time	10	Day
7	Incubation time	6	Day
8	Initial time	0	Day

1.

This data is extracted from the website of World Health Organization (WHO).

4.4. The Model Validation:

In addition to the aforementioned validation methodologies for the proposed system dynamic model (as presented in [23]), the following methodologies have been used in this research to verify the model:

•Simulation of reference behaviors

•Validation of the model structure

•Boundary conditions

As shown in Figure 7, through comparison of the number of new infections with both actual data for several major outbreaks, and simulated data based upon the proposed model, it has been confirmed that the proposed model can accurately simulate the reference behavior of newly infected individuals using the reference behavior reproduction methodology.

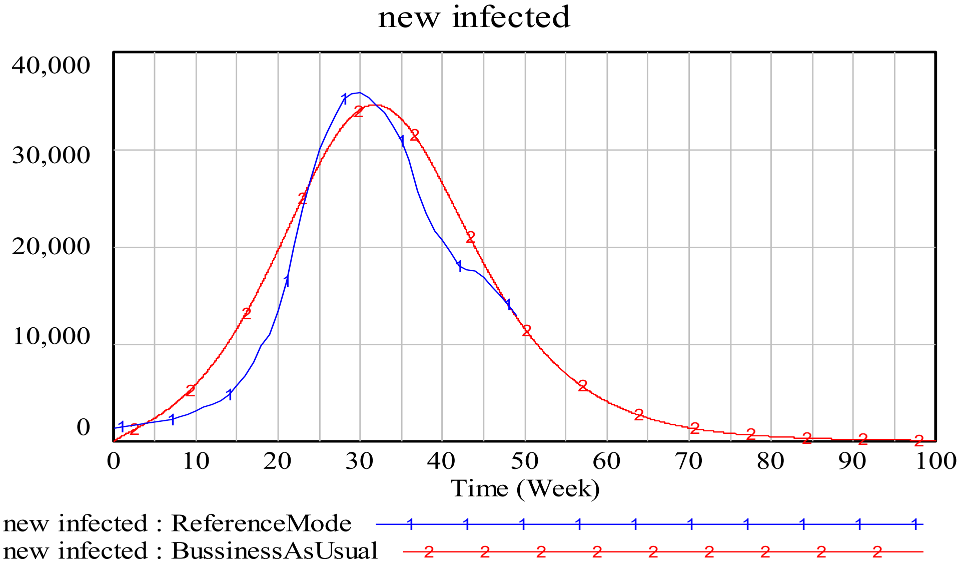
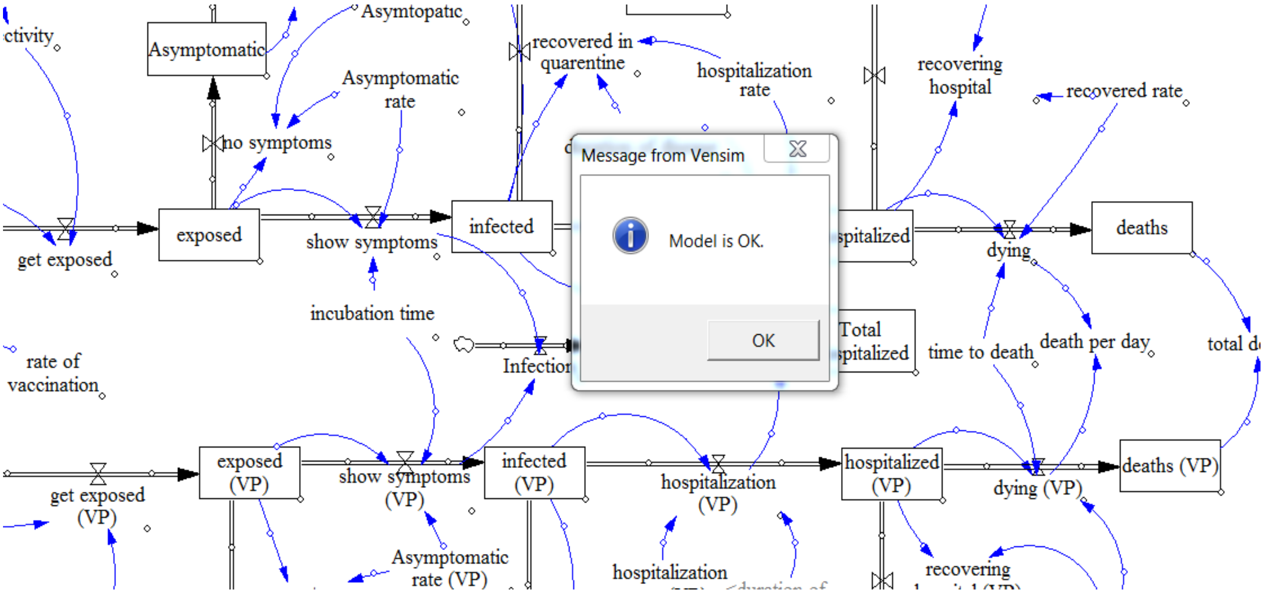


Figure 7: Comparing the Model Simulation Results and Historical Data Related to the Number of Newly Infected People

Structural validation of a model may be obtained by means of structural verification as well. Since the model has been developed according to Ovalle and Ibarra-Vega (2021) and therefore it follows their structure; thus, structural validation of the model will follow from this. Also, the Vensim software verifies the structural validity of the model as shown below using the same assessment standards. The results presented in Figure 8 are generated via the use of the Vensim software as illustrated in the Figure below:

The Boundary Condition Test represents yet a second form of verification of the model by demonstrating that the model will produce rational results with no pre-conditioned data (i.e., all people have been vaccinated at some point). As a result of this verification procedure shown in Figure 9, the validity of the model has been proven.


Message from Vensim

Model is OK.

Figure 8: The Model Validity in Terms of Structural Verification

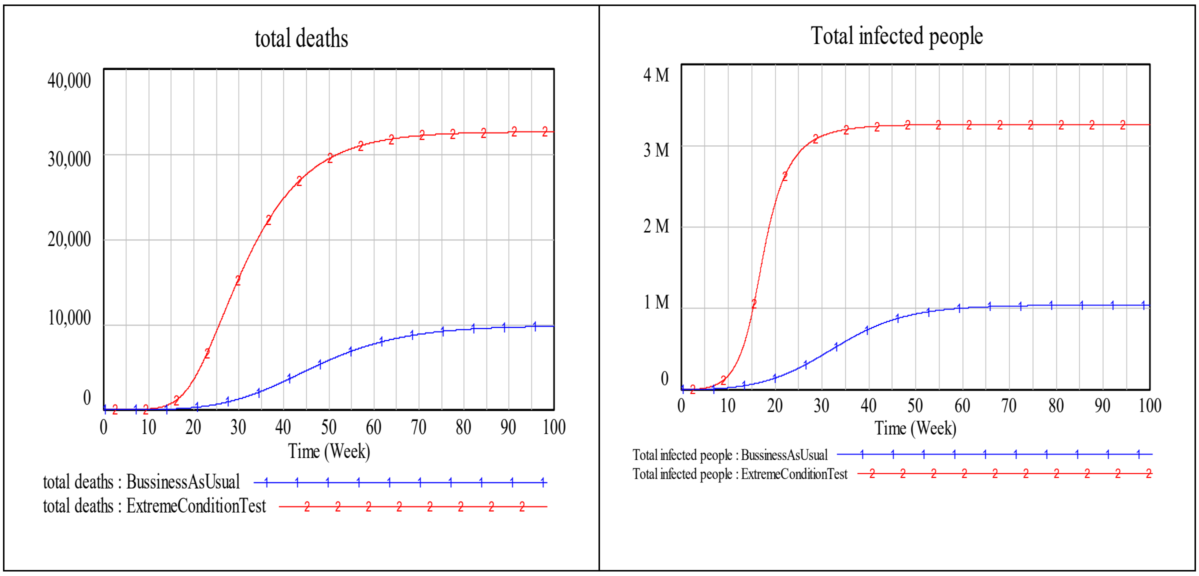
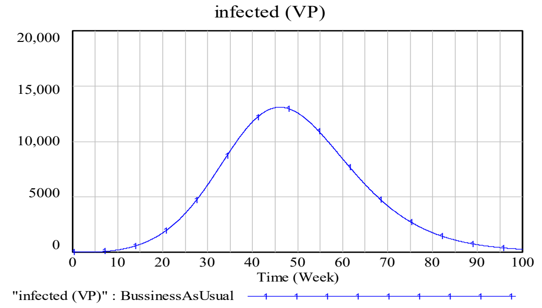


Figure 9: Model validation results with threshold test

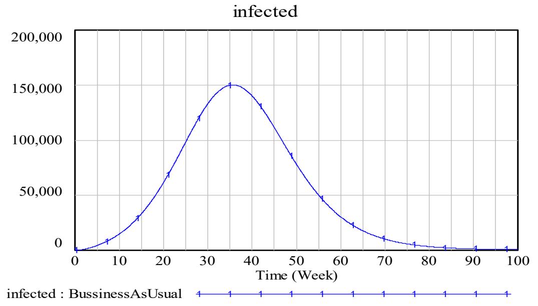
5. Findings

5.1. Scenario Analysis

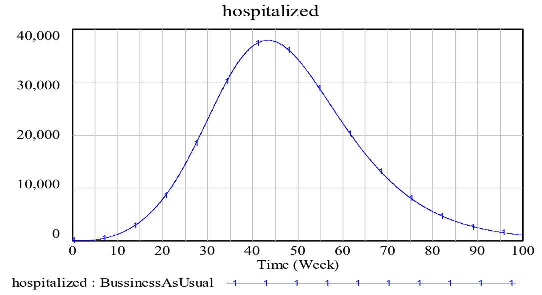
The first scenario is based on the idea that the country will remain stable for the 6th wave of COVID-19 which is a reflection of the government's reluctance to impose very restrictive measures to combat the disease. This scenario assumes that 62.5 percent of the population has been vaccinated by receiving two doses. An example of what would happen if the first scenario were to occur is presented as Figure 10.



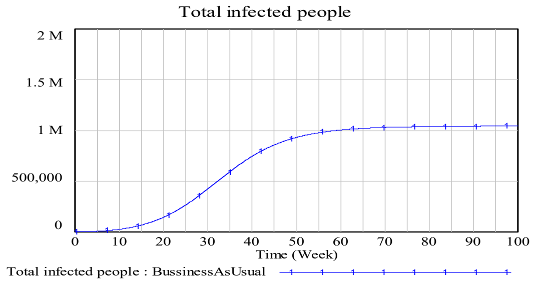
Number of Vaccinated People



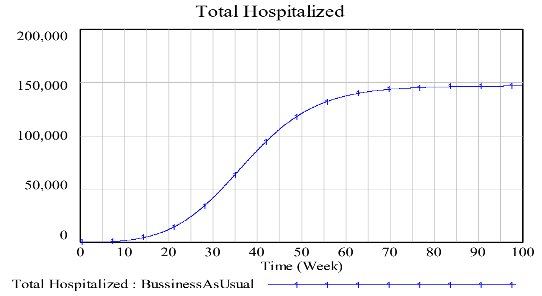
Number of Unvaccinated Patients



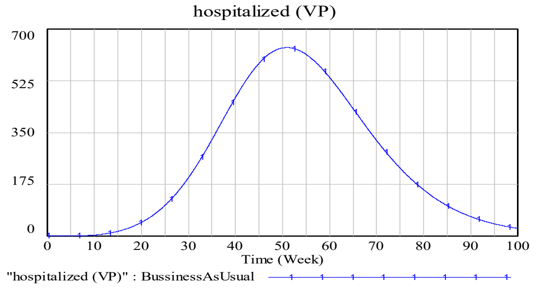
Number of Hospitalized Uninfected People



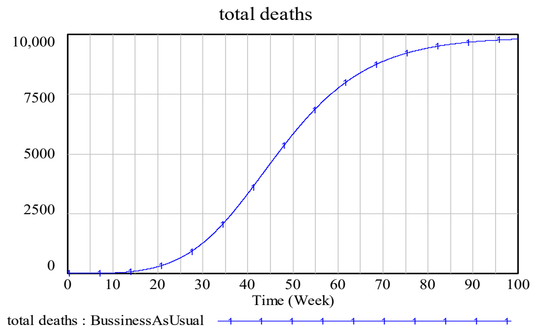
Total number of Infected People (aggregate)



Total Number of Admissions



Number of Hospitalized Vaccinated People

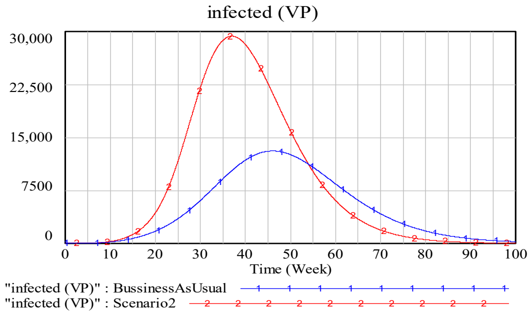


Total Number of Deaths

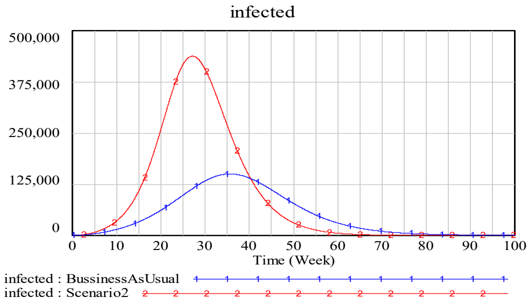
Figure 10. The result of Scenario one

In Scenario 2, we are assuming that 40% of the population was vaccinated when the Widespread Illness Outbreak began; previously we had assumed 62.5%. Therefore, with the new assumptions, the behavior of the model variables will differ and there will be an increase in the numbers of people who have been infected and deceased, as can be seen in Figure 11.

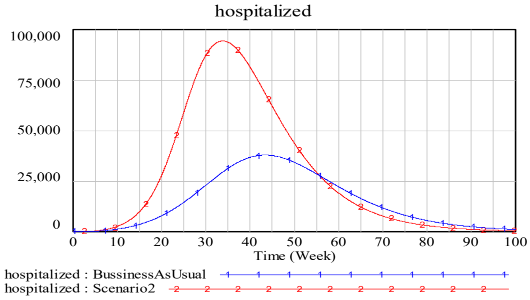
Scenario 3 examines the impact of Widespread Illness Restrictions. In Scenario 3, we examine a 30% reduction in the population that has the potential to become sick from the Widespread Illness. The results of these changes are demonstrated in Figure 12.



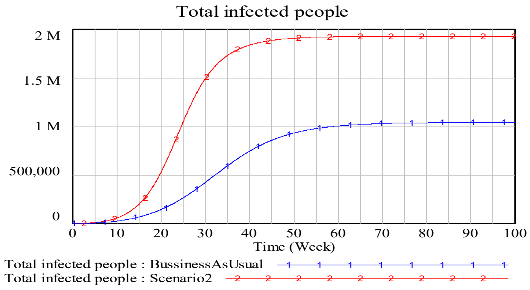
Number of Vaccinated People



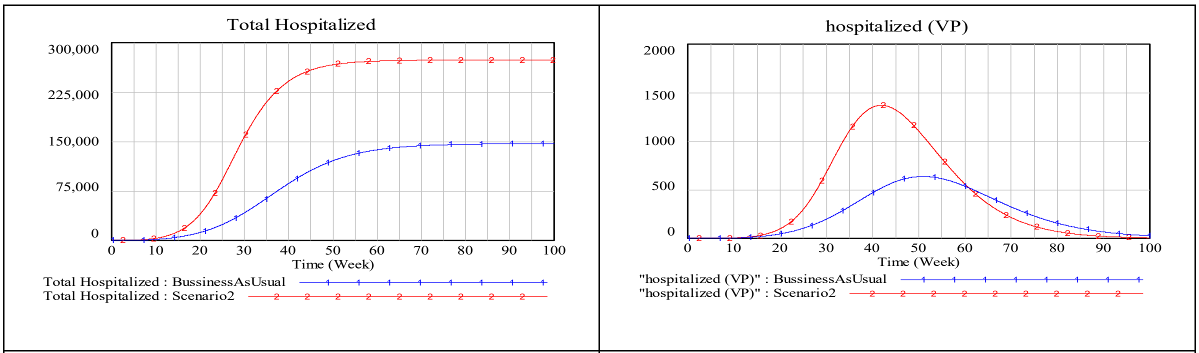
Number of Unvaccinated Patients



Number of Hospitalized Uninfected People

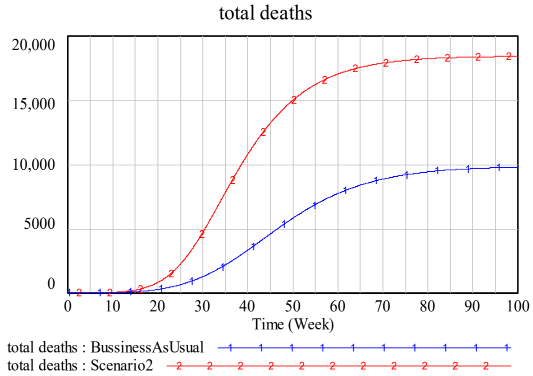


Total number of Infected People (aggregate)



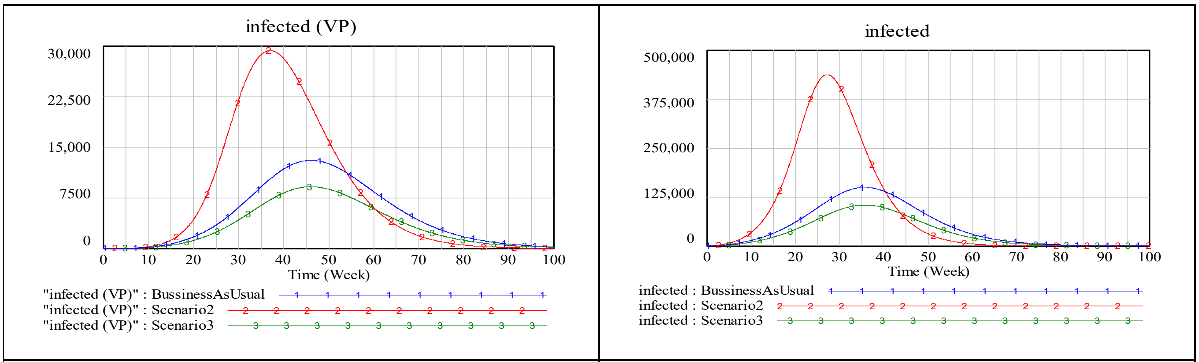
Total Number of Admissions

Number of Hospitalized Vaccinated People



Total Number of Deaths

Figure 11. The result of Scenario two



Number of Vaccinated People

Number of Unvaccinated Patients

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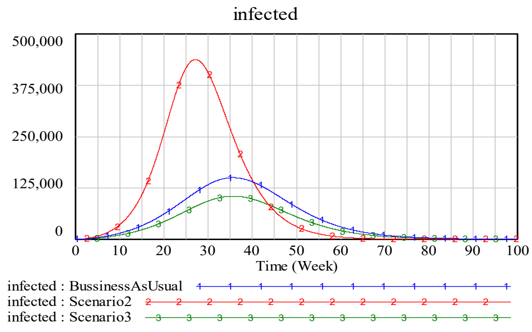
<td>
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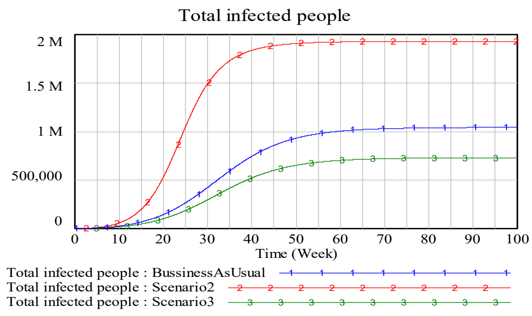
<td>
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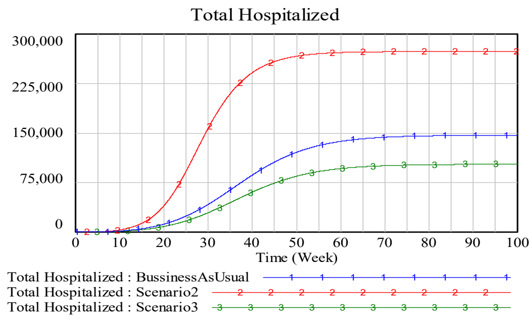
<td>
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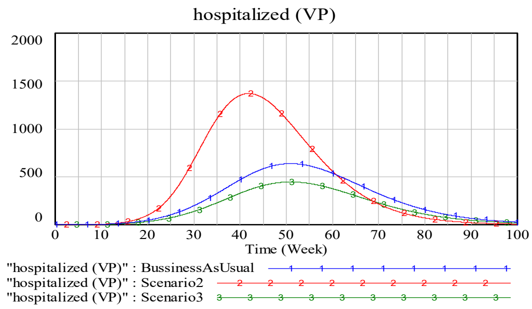
<td>
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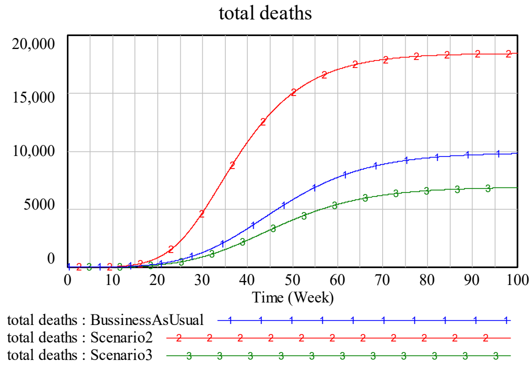
<td colspan="2">
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<td colspan="2">Total Number of Deaths</td>
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Figure 12. The result of Scenario two

5.2. Sensitive Analysis

Robustness testing included modifying key parameters (e.g., the percentage of the population vaccinated) by ±20%. In the beginning stages of increasing immunization rates, this had a negative impact on overall mortality rates. The mortality rate declined by approximately 20% as vaccination rates rose. The relationship between vaccine efficacy and mortality was shown to be inversely proportional; i.e., higher vaccine efficacy is associated with lower mortality rates. An increase in asymptomatic infections combined with longer periods of illness, contributed to a large increase in total mortality rates. A rapid identification of asymptomatic cases and prompt medical treatment could result in a large reduction in deaths. Longer hospitalizations provided improved patient outcomes and were also linked to reductions in mortality rates. Increased incubation time increased the potential for mortality due to the greater likelihood of transmission. These variables must be evaluated and managed appropriately so that they can be effectively used in preparation for a pandemic. Figure 13 illustrates the sensitivity test results.

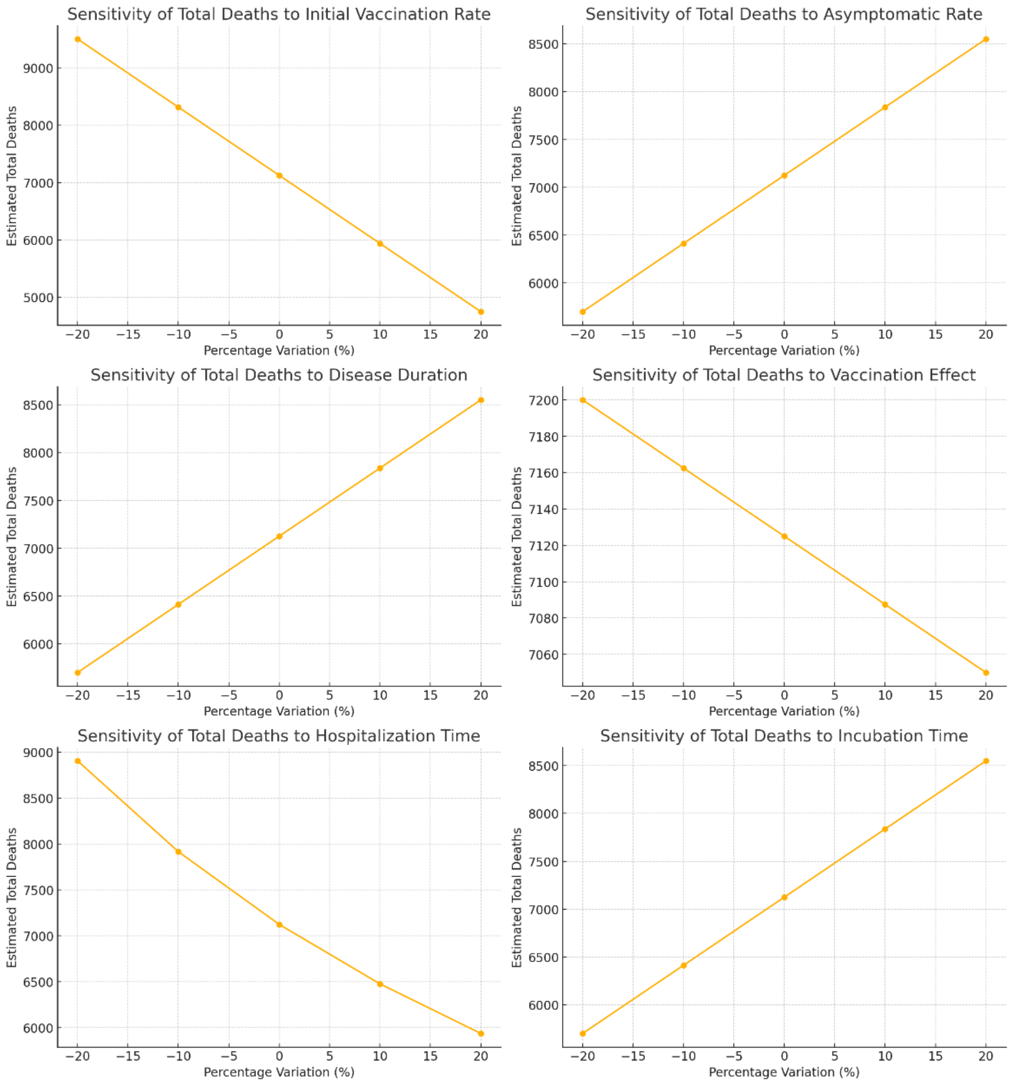

Figure 13. Sensitive analysis

6. Conclusion

Beginning in the early 20th century, many scientists have attempted to determine how common diseases behave within each of their respective countries. By doing so, they were hoping to better understand how to manage similar disasters when they occur again in the future. Several methods have been used by researchers to accomplish this goal; one of them is System Dynamics. This method allows decision makers to understand the behavior of the WIDESPREAD ILLNESS system. This paper attempts to improve our understanding of widespread illness in Iran, where Iran ranks among the highest mortality rates in the world.

In addition to providing greater insight into how knowledge obtained about common illnesses can be applied to other illnesses, the use of simulation will introduce a new model to analyze how vaccination impacts the height (peak) of WIDESPREAD ILLNESS waves, and the associated mortality rate. The model will describe the country's population into two groups, the vaccinated and the unvaccinated, and these groups will contain different coefficients and parameters.

This paper will utilize three different scenarios to formulate and then to simulate the model using scenario analysis.

Scenario 1: This will include continuing with the status quo. It is assumed that all model parameters are constant. Decision makers will be able to assess any potential variations in widespread illness behaviors to allow for timely government interventions such as city wide lock downs and renewed vaccination campaigns.

Scenario 2: This will represent the decreased percentage of vaccinated individuals (from 62.5% to 40%) at the start of an outbreak. This decrease represents an interval that has passed since the previous vaccinations, and therefore would be prudent to restart vaccinations prior to the emergence of a new WIDESPREAD ILLNESS wave.

Scenario 3: This will explore the effects of imposing WIDESPREAD ILLNESS related restrictions on the mobility of vulnerable populations (30% less). The effect of decreasing mobility of susceptible populations will be evaluated to assess the impact of this on disease transmission. Table 5 will outline the results of the three scenarios presented in this research.

Table 5- The Parameters of the Stock Variables

Scenario	Total Number of Patients		Total Number of Hospitalizations		Total Number of Deaths	
Scenario 1	1,042,990	0%	146,802	0%	9,802	0%
Scenario 2	1,928,820	84.9%	273,435	86.3%	18,416	87.8%
Scenario 3	730,095	-30.0%	102,762	-30.0%	6,861	-30.0%

Based on the table data provided, there is an apparent decline in vaccination levels from approximately 77.5% to as low as 55% leading to a dramatic increase in patient counts (85%), hospitalization rates (88%) and fatalities (89%). In contrast, restrictions which reduce the number of vulnerable individuals also lead to decreases in the number of patients, hospitalizations and fatalities. However, it should be acknowledged that this study has several limitations. The scope of this model is limited to the chosen system boundary and therefore does not incorporate secondary effects that could potentially affect the model. We are able to simulate medium- and long-term development of the primary variable trends through dynamic simulation; however, we lack the necessary detailed data to further refine our analysis. Researchers, however, may use this model as a basis for analyzing different dimensions of Iran's society and economy, etc.

Conflict of Interest statement: On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Data Availability Statement: Data will be available upon request from the correponding author.

Research Involving Human and /or Animals: Not applicable.

Informed Consent: Not applicable.

References

[1] A. R. Santhi and P. Muthuswamy(2022), “Pandemic, War, Natural Calamities, and Sustainability: Industry 4.0 Technologies to Overcome Traditional and Contemporary Supply Chain Challenges,” LOGISTICS-BASEL, vol. 6, no. 4, , doi: 10.3390/logistics6040081.

[2] H. Ge et al., “The epidemiology and clinical information about COVID-19(2020),” European journal of clinical microbiology & infectious diseases, vol. 39, pp. 1011–1019.

[3] I. Pavlova and M. E. de Boyrie(2022), “ESG ETFs and the COVID-19 stock market crash of 2020: Did clean funds fare better?,” Financ. Res. Lett., vol. 44, doi: 10.1016/j.frl.2021.102051.

[4] F. Pisani and G. Russo(2021), “Sustainable Finance and COVID-19: The Reaction of ESG Funds to the 2020 Crisis,” Sustainability, vol. 13, no. 23, , doi: 10.3390/su132313253

[5] N. S. Nurmohamed et al.(2022), “Lipoprotein(a), venous thromboembolism and COVID-19: A pilot study,” Atherosclerosis, vol. 341, pp. 43–49, doi: 10.1016/j.atherosclerosis.2021.12.008.

[6] S. G. Maji and P. Lohia (2024), “Assessing the effect of core and expanded ESG on corporate financial performance: COVID-19’s moderating role,” JOURNAL OF INDIAN BUSINESS RESEARCH, vol. 16, no. 2, pp. 244–264, doi: 10.1108/JIBR-07-2023-0233.

[7] D. Cucinotta and M. Vanelli (2020), “WHO declares COVID-19 a pandemic,” Acta bio medica: Atenei parmensis, vol. 91, no. 1, p. 157,

[8] S. G. Maji and P. Lohia(2024), “Assessing the effect of core and expanded ESG on corporate financial performance: COVID-19’s moderating role,” Journal of Indian Business Research, vol. 16, no. 2, pp. 244–264, doi: 10.1108/JIBR-07-2023-0233.

[9] M. Yadav, B. Dhingra, S. Batra, M. Saini, and V. Aggarwal(2024), “ESG scores and stock returns during COVID-19: an empirical analysis of an emerging market,” Int. J. Soc. Econ., doi: 10.1108/IJSE-10-2023-0819.

[10] E. ElHawary and R. Elbolok (2024), “The implications of COVID-19 on ESG performance and financial reporting quality in Egypt,” Journal of Financial Reporting and Accounting, doi: 10.1108/JFRA-08-2023-0469.

[11] A. Takian, A. Raoofi, and S. Kazempour-Ardebili (2020), “COVID-19 battle during the toughest sanctions against Iran,” The Lancet, vol. 395, no. 10229, pp. 1035–1036,

[12] R. Rezapour, A. A. Dorosti, M. Farahbakhsh, S. Azami-Aghdash, and I. Iranzad(2022), “The impact of the Covid-19 pandemic on primary health care utilization: an experience from Iran,” BMC Health Serv. Res., vol. 22, no. 1, p. 404,.

[13] R. Lotfi, K. Kheiri, A. Sadeghi, and E. Babaee Tirkolaee (2022), “An extended robust mathematical model to project the course of COVID-19 epidemic in Iran,” Ann. Oper. Res., pp. 1–25.

[14] J. T. Wu, K. Leung, and G. M. Leung(2020) “Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study,” The Lancet, vol. 395, no. 10225, pp. 689–697, doi: 10.1016/S0140-6736(20)30260-9.

[15] Y. Liu, A. A. Gayle, A. Wilder-Smith, and J. Rocklöv (2020) “The reproductive number of COVID-19 is higher compared to SARS coronavirus,” J. Travel Med., vol. 27, no. 2, doi: 10.1093/jtm/taaa021.

[16] A. R. Tuite, D. N. Fisman, and A. L. Greer(2020), “Mathematical modelling of COVID-19 transmission and mitigation strategies in the population of Ontario, Canada,” Can. Med. Assoc. J., vol. 192, no. 19, pp. E497–E505, doi: 10.1503/cmaj.200476.

[17] C. Bordehore, Z. Herrador, E. S. Fonfría, and M. Navarro(2020), “Understanding COVID-19 spreading through simulation modeling and scenarios comparison: preliminary results,” Apr. 01,doi: 10.1101/2020.03.30.20047043.

[18] R. M. Anderson, H. Heesterbeek, D. Klinkenberg, and T. D. Hollingsworth (2020), “How will country-based mitigation measures influence the course of the COVID-19 epidemic?,” The Lancet, vol. 395, no. 10228, pp. 931–934, doi: 10.1016/S0140-6736(20)30567-5.

[19] A. J. Kucharski et al.(2020), “Early dynamics of transmission and control of COVID-19: a mathematical modelling study,” Lancet Infect. Dis., vol. 20, no. 5, pp. 553–558, doi: 10.1016/S1473-3099(20)30144-4.

[20] Y. Huang(2024), “Do ESG ETFs provide downside risk protection during Covid-19? Evidence from forecast combination models,” International Review of Financial Analysis, vol. 94, doi: 10.1016/j.irfa.2024.103320.

[21] E. ElHawary and R. Elbolok(2024), “The implications of COVID-19 on ESG performance and financial reporting quality in Egypt,” JOURNAL OF FINANCIAL REPORTING AND ACCOUNTING, doi: 10.1108/JFRA-08-2023-0469.

[22] F. Kurniawan, S. N. Musa, B. Nurfauzi, R. Ferdian, and F. Khair(2024), “Container Terminal Performance: System Dynamic Approach with Port Capacity Constraints and ESG Integration,” Jordan Journal of Mechanical and Industrial Engineering, vol. 18, no. 1, pp. 59–73, doi: 10.59038/jjmie/180105.

[23] J. Sterman (2002), “System Dynamics: systems thinking and modeling for a complex world,”.