INTRODUCTION

The emergence of the coronavirus disease 2019 (COVID-19) pandemic at the beginning of 2020 has significantly impacted the global economy, health, and society. As of 5 July 2022, there have been 547,901,157 confirmed cases of COVID-19 worldwide, including a total of 6,399,899 deaths reported to WHO (WHO, 2020). Malaysia is no exception, being swept by the COVID-19 outbreak in early 2020. Since then, the Malaysian government had taken several comprehensive measures to control the spread of COVID-19 within the country and alleviate mass panic (Shah et al., 2020). The earliest countermeasure was the implementation of a movement control order (MCO) nationwide on 18 March 2020 (Povera & Harun, 2020). During the period of MCO, everyone was instructed to stay indoors, and all interstate and overseas travelling, along with mass gatherings across the country were prohibited. Only essential sectors were allowed to operate while all businesses were shut except shops selling food and daily necessities.

The implementation of MCO served to slow down the transmission chain within the community and at the same time provided the Ministry of Health the opportunity to trace, isolate, and manage all identified positive cases (Aziz et al., 2020). The implemented MCO was then gradually relaxed to Conditional MCO (CMCO) and Recovery MCO (RMO) when cases of COVID-19 declined steadily. During CMCO and RMCO periods, some of the restrictions imposed during MCO were eased. Nevertheless, easing restrictions in turn accelerated the spread of COVID-19 due to an increase in people’s movement and failure to adhere to the regulated standard operating procedures (SOPs). Whenever there was a spike in cases, the enforcement of MCO returned. Lockdowns were effective at the beginning of the pandemic to flatten the curve of COVID-19. However, in long run, this countermeasure has an adverse effect on the nation’s economy and society (Salim et al., 2020). Prolong confinement and physical distancing amplified stress and anxiety within the community (Moni et al., 2021; Shang et al., 2021). which then leads to pandemic fatigue where people are tired of all preventive measures and less likely to adhere to the regulated COVID-19 SOPs.
The Malaysian government started the nationwide vaccination program on 24 February 2021 (Anand, 2021) and by 30 December 2021, 97.6% of the adult population in Malaysia are fully vaccinated against COVID-19 (Bernama, 2021). While the national COVID-19 immunization program is a success, it is still a far cry from winning the battle against COVID-19. Despite the fact that vaccination effectively shielded people against severe illness and death, it does not prevent the spread of COVID-19. In late 2021, the world was alarmed by the emergence of a new COVID-19 variant which is more deadly than the previous COVID-19 variants. The Health Minister announced in July 2022 that Malaysia is at risk of entering a new wave of COVID-19 due to the upsurge of Omicron BA.5 sub-variant within the local community (Harun, 2022). This new variant is reported to be the most transmissible version of COVID-19 to date. With the potential rise of COVID-19 cases, there is a need to understand the interaction of previous and current implemented preventive measures in order to devise effective strategies that are capable of controlling the future escalation of COVID-19 without jeopardizing life and livelihood of the community as confinement and lockdown are no longer an effective measure.

The aim of this paper is to understand how one implemented countermeasure interacted with the other and collectively strengthen or weaken the spread of COVID-19 within the community in Malaysia. The role of community and public integrity is also observed in this study. This paper focuses on the preventive measures that were carried out to prevent the spread of COVID-19 in Malaysia (before the virus penetrated the community). A causal loop diagram, through the foundation of system dynamics, is developed to understand these interactions. The remainder of this paper is organized as follows: Section 2 briefly presents an overview of literature related to system dynamics and public integrity. Section 3 explains the essence of system dynamics methodology while section 4 provides a discussion on the results stemming from the developed causal loop diagram. Section 5 concludes the paper.

RELATED WORK

System Dynamics

Ever since the global outbreak of COVID-19, system dynamics have been used to solve issues related to curbing the pandemic chain. System dynamics is a methodology for framing, understanding, and analyzing complex systems and problems with the aid of computer modelling and simulation software (Azar, 2012). The system dynamics approach originated from the research of Professor Jay W. Forrester at the Massachusetts Institute of Technology in the late 1950s. While traditional analysis approaches focus on breaking down problems into smaller parts and solving them separately, system dynamics involves a broader view and focuses on looking at possible interactions among the subsystems to create a better understanding of the big picture (Cheng, 2010).

The need for system dynamics constantly arises as our best efforts to solve a problem actually make it worse due to our well-intentioned efforts to solve pressing problems to lead to policy resistance where policies are delayed, diluted, or defeated by the unforeseen reactions of other people or nature (Sternman, 2000). System dynamics, therefore, is a powerful method to gain useful insights into situations of dynamic complexity and policy resistance. It is increasingly used to design more successful policies in companies and public policy settings (Sternman, 2000).

Bradley et. al. (2020) mentioned that the systems approach is able to help policymakers to look beyond the chain of COVID-19 infection and allow a better understanding of how to prevent and respond to the pandemic without affecting the community. The first study focusing on the application of system dynamics to the COVID-19 outbreak was done by Sy et. al (2020) who proposed several policy developments such as increasing public health capacity, community quarantine, and gradual lifting of quarantine, to name a few. The impact and effectiveness of these interventions were then simulated and observed.

Researchers from different countries had also made use of the advantages portrayed by system dynamics to solve COVID-19-related issues in their home countries. For instance, Niwa et. al. (2020) investigated the effectiveness of several social measures implemented in Japan to combat COVID-19 outbreaks through system dynamics modelling. Zhao et. al. (2020) observed the structure of COVID-19 transmission through the implementation of infection, prevention, and control policies during the work resume phase in Shanghai using system dynamics while a study was conducted in Korea by Lee et. al. (2020) to review the dynamics response of healthcare mask production during COVID-19.

The spread of COVID-19 and its effect on Indonesia’s economy was modelled by Sihombing et. al. (2020) using system dynamics. Another interesting study was carried out by Venkateswaran and Damani (2020) where they developed a customized system dynamics model for India to calibrate the effectiveness of several actions such as testing, tracing, social distancing, and hygiene in tackling COVID-19. Price and Propp (2020) developed a framework for assessing different late-stage models of COVID-19 through an extensive study conducted in Virginia where the study aimed at aiding policymakers through the developed system dynamics model to determine the plans to relax physical distancing by strategy.

Public Integrity

Integrity is driven by a person’s willingness to act according to the internalized values, beliefs, norms, and principles that constitute their moral compass (Sajari et al., 2019). The importance of ethics and integrity should be emphasized to reduce unethical behaviour within society. Several attempts have been made to show the importance of public integrity in controlling the spread of COVID-19 in Malaysia. The Malaysia Ministry of Health emphasized stricter rules, where
individuals who fail to report positive antigen rapid test results for COVID-19 may face fines up to RM5,000. This is also in accordance with the Infectious Diseases Act, where it is a crime not to declare a positive test result via the MySejahtera application. Therefore, living with COVID-19 increases the importance of personal and community social responsibility (Han & Abu Bakar, 2022).

Economists examine this rule through the lens of contract theory where incentives are given to encourage or discourage specific behaviours. An example is by assuming individuals tested positive. If self-isolation is done as it is the right thing to do even in the absence of rules, thus, openly and honestly reporting the result is irrelevant (as long as it is effortless to do, which it is for most people). According to contract theory, the RM5,000 fine is likely to reduce tests by those who are unwilling or unable (due to financial reasons) to voluntarily isolate (Holden, 2022).

On the other hand, the mandatory COVID-19 diagnostic testing and 14-day quarantine are two specific health measures that secured the industry's reopening, particularly for international business transactions. According to recent research, these practices help control the spread of COVID-19 infection (Wells, Townsend & Pandey, 2021). However, isolated cases of COVID-19 diagnostic testing certification fraud have been reported in some countries, including the Philippines and India. The fraudulent act may raise serious ethical and economic concerns because it involves deception and lying. It would destabilize the world's recovering economy by unleashing a new wave of COVID-19 infection as the virus' asymptomatic carrier would be free to travel using a forged document.

If not taken seriously, falsifying documents certifying a person who has received COVID-19 vaccination could occur later. In order to address such misconduct, there is a need for a social control mechanism where a special body is mandated to investigate anyone found guilty of misconduct (Ayodele, Cheng, Haron, & Dabor, 2020). In the context of managing a pandemic, the government has a moral and legal obligation to protect the general public from such unethical and illegal behaviour. The government's intervention must include the implementation of preventive measures to counteract the potential malpractice of using forged COVID-19 diagnostic tests and vaccination certifications. At the same time, the government must accept some responsibility. With the global economy in a state of emergency, individuals must exercise their social responsibility by avoiding and reporting any fraudulent COVID-19 tests, vaccines, or treatment to the appropriate authorities.

From a different perspective, when quarantine measures are relaxed, different protocols must be followed if one wishes to return to work or travel (Gozum et al., 2021). When quarantine measures are relaxed, there are people who faked COVID-19 diagnostic tests and vaccination certifications. As a result, various individuals' dishonesty impacted virus mitigation. Citizens should be truthful, honest, and transparent in their COVID-19 test declarations (Deguma & Deguma, 2021; Gozum et al., 2021).

Honesty is the quality of being truthful and free of deception, which is necessary for human relationships. This quality is critical for maintaining public health during the COVID-19 pandemic (Wells & Molina, 2017). The government should closely monitor all health facilities to ensure that the protocol for declaring COVID-19 test results and vaccination certification is strictly followed (Sarmiento, Yap, Espinosa, Ignacio, & Caro, 2021). The COVID-19 pandemic has instilled widespread scepticism in the public about the government's ability to conduct nationwide testing, produce reliable and effective vaccines, as well as educate the public on the efficacy and side effects of vaccines. These concerns created fear and distrust, making people hesitant to get vaccinated (Cohen, 2021).

With the government's strong political will to have true, honest, and transparent leadership and governance, the question of the truthfulness, honesty, and transparency of authentic and precise COVID-19 test results and vaccination certifications can be addressed (Kaplan, 2018). Besides that, timely and accurate information pertaining to COVID-19 should also be released by the government. Without a proper channel to retrieve information, the general public will rely on social media where the information is unreliable (Azizul & Kumaruddin, 2021).

Several studies have utilized system dynamics to improve integrity during the COVID-19 pandemic. Currie et al. (2020) developed a system dynamics model to assess the potential contribution of mobile smartphone tracing applications to control COVID-19. Gazzeh et al. (2022) on the other hand sustained the integrity and the impact of flows on urban system dynamics.

**SYSTEM DYNAMICS METHODOLOGY**

Since the original publication appeared roughly 60 years ago (Relić & Božikov, 2020), the application of system dynamics has substantially increased along with its capability to solve many real-world modelling issues (Richardson, 1996). System dynamics is widely employed in research, across a wide range of industries, businesses, and even public health policy plans. The strength of system dynamics modelling encourages policymakers to utilize system dynamics as an analysis tool to improvise management and devise policies. The application of system dynamics has been generally acknowledged in creating modifications and improvements, particularly in policy making and at the introduction of a new situation.

System dynamics simulation entails creating a model of a system in order to investigate the system that has an impact on the issue being researched. This method simplifies the system in some ways but is sufficiently detailed to allow appropriate inferences on the actual system (Sadiku & Ilyas, 1995). The vast array of real-world systems being represented may include existing or hypothetical systems that may not yet exist. A system is typically modelled using either logic or mathematics. The program is frequently used to mimic the features and operations of the system. With the system
In developing models using system dynamics, the construction of a causal loop diagram is a core concept. It is an important element to represent the structure of system feedback (Sterman, 2000). The system's structure determines how the system behaves. By changing the structural connections, the system can be more easily visualized.

Causal Loop Diagram

In system dynamics modelling, the negative or positive feedback process is often represented by a causal loop diagram. A causal loop diagram is a conceptual tool that reveals the concept of a dynamic process where the chain of causes and effects are recognized through related variables and looping to the original cause or effect (Maani & Cavana, 2000). Therefore, it demonstrates the causal relationships between individual system variables and provides an understanding of the root causes of dynamics, improving mental models and is great for delivering important feedback that caused problems (Sterman, 2000). The flexibility to graphically represent the feedback structure of complex systems makes the causal loop diagram a useful tool.

In a causal loop diagram, variables are connected by causal links indicated by arrows. A reinforcing loop or positive correlation means that as the cause increases, so does the effect, and if the cause decreases, the effect will decrease as well. Conversely, a balancing loop or negative connection signifies inverse influence where when the cause increases, the effect decreases, and if the cause decreases, the effect increases.

Figure 1 shows a simple causal loop diagram example between the reinforcing loop and balancing loop of chickens and eggs. Here, the reinforcing loop is depicted with the symbol R where when more eggs are laid, the number of chickens increases. Increasing the number of chickens in turn will produce more eggs. On the other hand, the balancing loop (denoted by the symbol B) will work to balance the chicken population as it grows. For instance, when the number of chickens increases, more of the chicken will seek to cross the road, increasing the likelihood of accidents with moving cars. Fatalities due to road crossings, therefore, reduced the number of chickens. The positive links (plus sign) denote connections where the cause and effect grow together as the cause rises while negative linkages (minus sign) are those in which the effect increases when the cause lowers and decreases when the cause increases.

RESULTS AND DISCUSSION

The enforcement of SOPs, movement restrictions, vaccination program, as well as tracking, screening, and testing are strategies administered in Malaysia to break the transmission of COVID-19. The SOPs include donning a face mask in public and updating and scanning the MySejahtera apps as a guideline for businesses and service sectors that are allowed to operate. This SOP is also enforced on those who are doing religious activities, sports, and recreation activities. Movement restrictions are in the form of MCO, CMCO and RMCO lockdown. In the early stage of the pandemic, the Ministry of Health conducted mass tracking, screening, and testing within the community prevalent to COVID-19. By mid of 2021, the COVID-19 self-test kit is made available so that the public can conduct the test themselves.

These preventive measures are depicted in Figure 2 through the development of a causal loop diagram. There are a total of four balancing loops and four reinforcing loops where reinforcing loops are denoted by an R while B represents the balancing loops. Balancing loop B1 describes the tracking, screening, and testing of preventive measures while balancing loops B2 and B4 reveal the dynamics of the implemented movement restriction measures. Balancing loop B3
along with reinforcing loops R4 and R3 present the intricacies of SOPs enforcement in Malaysia. The complexity of all reinforcing and balancing loops will be demonstrated next.

The reinforcing loop R1 explains that an increase in the spread of COVID-19 will escalate the number of people exposed to the virus which in turn will further increase the spread of COVID-19. When the number of people exposed to COVID-19 is higher, the tendency of people to get infected with the disease increases, as depicted in reinforcing loop R2. Balancing loop B1 shows that, by increasing tracking, screening, and testing of the exposed population, the spread of COVID-19 can be reduced.

Balancing loop B2 exhibits in cases where the spread of COVID-19 surged, movement restriction is restored to reduce human mobility, therefore, reducing the spread of COVID-19. This loop can be further extended to balancing loop B3 where decreasing human movement and interaction further reduce SOP violations as the community is contained at home. This will then reduce the outspread of COVID-19. However, reinforcing loop R3 tells the flip side of lockdown where increasing movement restriction inevitably increases pandemic fatigue where people grew tired of adhering to the regulated SOPs, thus increasing SOP violation and in the end contributing to the increase in COVID-19 transmission.

Reinforcing loop R4 portrays a similar situation where tighter movement restriction poses an adverse impact on the economy as many businesses are forced to either operate with minimal capacity or temporarily shut down. The slowdown in economic activities over a period of time will impact people’s livelihoods as people lose their job. This is evident through the emergence of the Bendera Putih movement where struggling Malaysian call out for aid. Unstable livelihood increases pandemic fatigue and triggers more SOP violations and contributes to the increase of the spread of COVID-19. Balancing loop B4 illustrates that a prolonged movement restriction further triggers pandemic fatigue. The escalation of pandemic fatigue sparks mental health issues and suicidal cases in the community which increases the pressure to relax movement restrictions.

The developed causal loop diagram also exhibits auxiliary factors that may increase or reduce SOP violations. It is important to understand these variables as adhering to or violating the SOPs influence the spread of COVID-19. Accelerating the national vaccination process increases the number of vaccinated populations. However, vaccinated people tend to violate the SOPs and in turn, spread the virus. There are also groups in a community that are in denial of the threat posed by COVID-19. These COVID-19 sceptics are also prone to bypass the regulated SOPs.

Apart from factors that escalate SOPs violation and the spread of COVID-19, there are also factors that lead the public to adhere to the regulated SOPs. By increasing the community awareness of the need to obey the stipulated SOPs, the number of SOP violations will be reduced. Providing widely available, accurate, and transparent information through the official governmental website, channels, as well as awareness campaigns, builds trust and understanding among the people. Fines and penalties are also effective in reducing SOP violators. In times when the number of death due to COVID-19 rises, fear and anxiety magnify within the community, therefore, reducing SOP violations. A summary of feedback loops that explained the impact of the implemented COVID-19 preventive measures is illustrated in Table 1.

![Figure 2. Causal loop diagram of COVID-19 preventive measures implemented in Malaysia](journal.ump.edu.my/gji)
Therefore, the community from the threat of new COVID-19 variants. For future research, the causal loop diagram also reveals that a decline in SOP compliance will escalate the spread of COVID-19. Most of the SOP violations are man-made which signifies that the community is largely oblivious to the fact that the battle against COVID-19 could not be won by only relying on the preventive measures implemented by the government. There are incidents where people who are not vaccinated opt to buy fake vaccination certificates to avoid restrictions imposed on the unvaccinated. Other examples of lacking integrity within the community are reporting untruthful information to the MySejahtera apps, hiding the fact of being infected by COVID-19, resisting to participate in mass testing and self-administered test, failing to practice social distancing and putting the mask on in public, avoiding quarantine, and running away from the quarantine centre. These actions put others and even the entire nation at risk of escalation in the COVID-19 outbreak.

As mentioned by Salleh and Heidecke (2019), human governance is understanding the aspects of being human in regards to the “what”, the “who” and the “why”. The “who” and “why” are essential to reflect upon our role within the community, why we do what we do and what are the consequences of our actions. Therefore, the community plays a huge role in sharing the responsibility of breaking the COVID-19 chain. Instead of adhering to the SOPs for the fear of fines, public integrity and human governance in the form of the awareness to adherence should be for the collective good.

Turi et al. (2018) quoted the disaster management cycle theory where the framework consists of mitigation, preparedness, response, and recovery. This is in line with Malaysia as the nation is moving towards the recovery phase where the economy and community are returning to normalcy. With that being said, the government ought to devise policies in accordance with the recovery phase to bring back the affected community to normal life, which is post-COVID-19.

**CONCLUSION**

Although much of the SOPs are relaxed since Malaysia entered into the transition to the endemic phase on 1 April 2022, the threat of a more deadly and transmissible version of COVID-19 is still prevalent. The emergence of new COVID-19 variants will exacerbate the spread within the community with the alarming number of death without effective COVID-19 preventive measures. The developed causal loop diagram demonstrates the interaction of currently and previously implemented COVID-19 preventive strategies in Malaysia. Interdependencies and interrelationships among strategies such as SOPs regulation, movement restriction, vaccination programs, and mass tracking and testing provide a clear visualization of how these countermeasures collided and ultimately served to reduce or increase the spread of COVID-19 within society.

Understanding this push and pull relationship is important to recognize if these implemented preventive measures are capable to prevent the spread of COVID-19 in long run. It is evident that previously implemented countermeasures such as lockdown in the form of movement restrictions are no longer efficacious in containing the virus as long-term confinement has an adverse impact on the nation’s economy and the community’s livelihood. The emergence of pandemic fatigue due to prolong movement restriction and strict SOPs regulation are also revealed in the finding of this study. Pandemic fatigue triggers more SOPs violations and in turn escalates the spread of COVID-19. Movement restriction or MCO has proven to be a costly measure to control the spread of COVID-19.

Now more than ever, rather than depending on government intervention, the responsibility should also be shared by the community. In long run, public integrity through community solidarity and individuals’ responsibilities will be more effective in shielding the community from the threat of new COVID-19 variants. For future research, the causal loop

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Table 1. Summary of feedback loops representation on COVID-19 preventive measures implemented in Malaysia

<table>
<thead>
<tr>
<th>Feedback Loop</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Increase Spread of COVID-19 &gt; Increase Exposed Population &gt; Increase Spread of COVID-19</td>
</tr>
<tr>
<td>R2</td>
<td>Increase Spread of COVID-19 &gt; Increase Exposed Population &gt; Increase Infected Population &gt; Increase Spread of COVID-19</td>
</tr>
<tr>
<td>R3</td>
<td>Increase Spread of COVID-19 &gt; Increase Movement Restriction &gt; Increase Pandemic Fatigue &gt; Increase SOP Violation &gt; Increase Spread of COVID-19</td>
</tr>
<tr>
<td>R4</td>
<td>Increase Spread of COVID-19 &gt; Increase Movement Restriction &gt; Increase Impact on the Economy &gt; Increase Impact on People Livelihood &gt; Increase Pandemic Fatigue &gt; Increase SOP Violation &gt; Increase the Spread of COVID-19</td>
</tr>
<tr>
<td>B1</td>
<td>Increase Spread of COVID-19 &gt; Increase Exposed Population &gt; Increase Tracking, Screening &amp; Testing &gt; Reduce Spread of COVID-19</td>
</tr>
<tr>
<td>B2</td>
<td>Increase Spread of COVID-19 &gt; Increase Movement Restriction &gt; Reduce Human Mobility &amp; Interaction &gt; Reduce Spread of COVID-19</td>
</tr>
<tr>
<td>B3</td>
<td>Increase Spread of COVID-19 &gt; Increase Movement Restriction &gt; Reduce Human Mobility &amp; Interaction &gt; Decrease SOP Violation &gt; Reduce Spread of COVID-19</td>
</tr>
<tr>
<td>B4</td>
<td>Increase Movement Restriction &gt; Increase Pandemic Fatigue &gt; Increase Pressure to Relax Movement Restriction &gt; Reduce Movement Restriction</td>
</tr>
</tbody>
</table>

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diagram can be expanded to include countermeasures implemented once the spread of COVID-19 penetrated the community along with the implication to the healthcare system.

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**CONFLICT OF INTEREST**

The author(s), as noted, certify that they have NO affiliations with or involvement in any organisation or agency with any financial interest (such as honoraria; educational grants; participation in speakers’ bureaus; membership, jobs, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, expertise or beliefs) in the subject matter or materials addressed in this manuscript.

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