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Evaluation of the effectiveness of government intervention strategies to control and prevent COVID-19 in Malaysia by systems thinking

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Abstract

Purpose – This paper aims to identify the interaction of different intervention strategies implemented in Malaysia towards flattening the curve of COVID-19 cases. Since the outbreak of COVID-19, many approaches were adopted and implemented by the Malaysian government. Some strategies gained quick wins but with negative unintended consequences after execution, whereas other strategies were slow to take effect. Learning from the previous strategies is pivotal to avoid repeating mistakes.

Design/methodology/approach – This paper presents the cause, effect of and connection among the implemented COVID-19 intervention strategies using systems thinking through the development of a causal loop diagram. It enables the visualisation of how each implemented strategy interacted with each other and collectively decreased or increased the spread of COVID-19.

Findings – The results of this study suggested that it is not only essential to control the spread of COVID-19, but also to prevent the transmission of the virus. The Malaysian experience has demonstrated that both control and preventive strategies need to be in a state of equilibrium. Focusing only on one spectrum will throw off the balance, leaving COVID-19 infection to escalate rapidly.

Originality/value – The developed feedback loops provided policy makers with the understanding of the merits, pitfalls and dynamics of prior implemented intervention strategies before devising other effective intervention strategies to defuse the spread of COVID-19 and prepare the nation for recovery.

Keywords Intervention strategy, COVID-19 pandemic, Systems thinking, Causal loop diagram, Malaysia

Paper type Research paper

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Introduction

Coronavirus (COVID-19) is an infectious respiratory disease caused by a newly discovered coronavirus. The COVID-19 outbreak started in Wuhan City, Hubei Province, China. In December 2019, the Huanan Seafood Wholesale Market was identified as the possible point of origin of COVID-19 infection. Since then, this infectious disease has spread to nearly every region of the globe. Owing to the outbreak's alarming level of spread and severity, on 11 March 2020, the World Health Organization declared the COVID-19 outbreak as a global pandemic (WHO, 2020a). As of 30 September 2021, a total of 233,184,584 cases of COVID-19 have been confirmed, including 4,777,009 deaths (WHO, 2021).

The first case of COVID-19 in Malaysia was detected on 25 January 2020 (Zack, 2020); since then, Malaysia has been in a fierce battle against COVID-19. Twenty months after the first detected case, the number of daily confirmed cases showed prominent decrease in September 2021 owing to the nationwide vaccination programme as depicted in Figure 1. As of 30 September 2021, Malaysia has witnessed a total of 2,232,960 confirmed cases of COVID-19 with 26,143 deaths (WHO, 2021).

The earliest counter measure to prevent the wide spread of COVID-19 in Malaysia was through the enforcement of Movement Control Order (MCO) on 18 March 2020 (Povera and Harun, 2020). This restriction of movements included barring interstate and overseas travelling, prohibiting mass gatherings across the country, and shutting all businesses, except shops selling food and daily necessities. Three months (as of 10 June 2020) through the implementation of the MCO, the COVID-19 curve in Malaysia was flattened significantly, and it marked the enforcement of the recovery MCO. During this phase, other restrictions were relaxed, allowing interstate travelling, resumption of social and religious activities and the opening of schools and universities (Povera and Chan, 2020). Unfortunately, Malaysia witnessed the horror of a third-wave spike in COVID-19 cases starting at the end of September 2020. Subsequently, the Malaysian government decided to implement a conditional MCO from 9 November 2020 to 6 December 2020 on nearly all states in Malaysia (Daud, 2020). Interstate travelling was not allowed during the phase of the conditional MCO, and only essential businesses were permitted to operate.

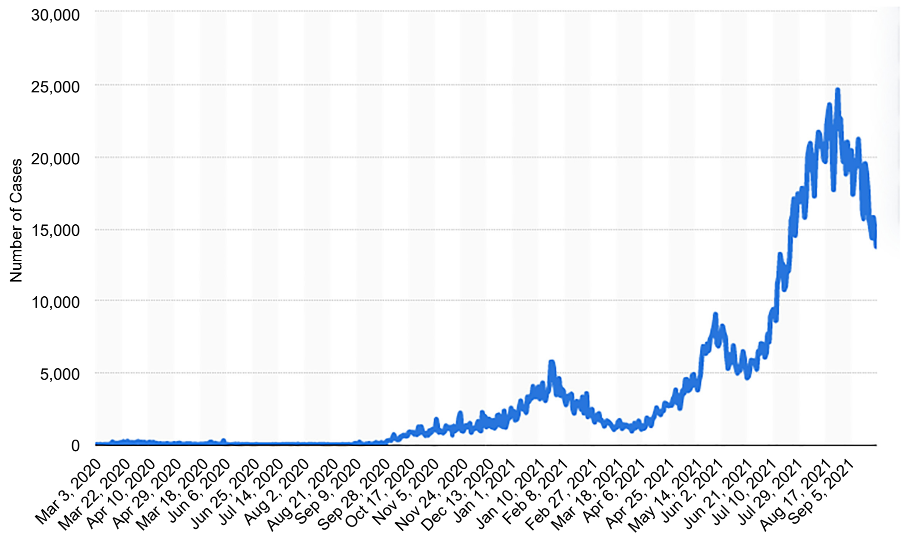

Figure 1. Number of daily confirmed COVID-19 cases in Malaysia from March 2020 to September 2021
Source: MOH (2022)

Ever since the spike of the third wave in September 2020, the COVID-19 cases fluctuated in an ascending trend, which later compelled the Malaysian government to place the nation under total lockdown (full MCO) in June 2021 for an indefinite period until further notice (Ram, 2021). In late September 2021, the number of COVID-19 cases started to show signs of downturn with the full enforcement of a nationwide vaccination programme. Entering October 2021, Malaysia eased the movement restriction by allowing interstate travelling and all businesses to resume operation after a year of cessation.

Malaysia was committed towards vaccinating the population by the end of 2021. Although COVID-19 vaccine does protect people against severe illness and death due to the virus, the vaccine does not prevent the spread of COVID-19. Additionally, the threat from more deadly new variants of the COVID-19 exists. Therefore, the risk of a surge in COVID-19 cases surfaces as people start to resume their daily interactions as well as travelling interstate and internationally.

Putting the nation in another lockdown is a costly measure as it affects the people's livelihood and places Malaysia's economy at risk of collapsing (Tan, 2021). The prolonged confinement has caused many people to face financial struggles, unemployment, depression as well as other mental health issues. Lockdown is no longer a sustainable measure to contain the virus. The Health Ministry Malaysia recognised the need for a circuit breaker to stop the outbreak of infection other than resolving with full-scale lockdown or movement restriction across the country should the infection cases rise again in the future (Yunus and Yusof, 2021).

This study presents the use of systems thinking through the development of a causal loop diagram in which various governments' responses to the COVID-19 pandemic are visualised by means of feedback loops. By linking these feedback loops, a clear pattern of behaviours representing the merits and pitfalls of the implemented measures against COVID-19 infection will emerge.

Literature review

Overview of systems thinking

A system consists of interrelated and interdependent parts working together where every change in one part of the system affects other parts and the entire system. The nature of systems is interconnected, fused with feedback and delays, which intensify the dynamic complexity. Even when confronted with a seemingly simple dynamic problem, the human mind has difficulty comprehending and making decisions (Sterman, 2000). Traditional problem-solving approaches tend to break the problem into smaller parts and tackle each part individually. By thinking in systems, Whitehead *et al.* (2015) affirm that all the encompassing aspects of a system will be considered to innovate change and determine optimal solutions that will collectively achieve the system's objective.

Barry Richmond, a system scientist, credited with introducing the term systems thinking in 1987 (Arnold and Wade, 2015), defines systems thinking as the art and science of making reliable inferences about behaviour by developing an increasingly deep understanding of the underlying structure (Richmond, 1994). Most sources accord that systems thinking embraces holistic thinking instead of dissected thinking, with focus on the relationships among system components rather than individual components (Monat and Gannon, 2015).

Systems thinking enables systems to be re-designed by actively creating desirable results after identifying the root cause and focusing on the right vital leverage areas (Hassan *et al.*, 2020). As the world is now increasingly complex, uncertain and intertwined, the need arises for a method which can effectively solve complex problems with many interrelated components. Systems thinking particularly shines in areas of strategy, such as discovering hidden opportunities, untapped leverages and internal contradictions, which are often neglected by other methodologies (Cavana and Maani, 2000).

Government bodies and industry sectors have utilized systems thinking in numerous areas, particularly for strategy or policy formulation and testing (Cavana and Maani, 2000). In managing disasters, systems thinking is applied to recommend effective long-term flood disaster response policies by identifying key stakeholders and factors for disaster risk reduction in Pakistan (Rehman *et al.*, 2019). Islam *et al.* (2022) used systems thinking for a holistic understanding of Bangladesh's disaster and climate change impacts on agriculture to advise the government about effective intervention programmes. Within the theme of disaster management, Lin and Chien (2019) applied systems thinking to explore the root cause of the Kaohsiung gas explosion disaster; the developed causal loop diagram revealed that safety management was compromised to expedite production and pipe line control.

Shams Esfandabadi *et al.* (2020) developed a causal loop diagram to analyse the environmental effects of car-sharing services and proposed relevant strategies to track the causes of changes in the environmental impacts. Similarly, Laimon *et al.* (2022) adopted systems thinking to analyse current energy development policies in Australia with aims to improve and support sustainable energy development policy. Systems thinking is also used to evaluate China's marine fisheries management system and determine how interaction among stakeholders affects the convergence to sustainable fisheries management in the study by Su *et al.* (2022). Sunitiyoso *et al.* (2022) explored the interactions among stakeholders to understand maritime logistics systems in Indonesia for performance improvement and intervention, whilst Kim *et al.* (2021) used systems thinking to explore potential strategies for South Korea's automotive retail industry in facing the impact of technological disruption.

Systems thinking and COVID-19

The systems thinking approach has been widely used with regard to public health issues before the COVID-19 crisis (Diez Roux, 2020; Gonella *et al.*, 2020; Zięba, 2021). The COVID-19 pandemic has vividly brought systems interconnectedness to the forefront of human thinking (Hassan *et al.*, 2020). Luke and Stamatakis (2012) asserted that society operates akin to a complex adaptive system; hence, systems thinking is capable of enlightening policymakers by helping them understand and influence the spread of infection and observe the consequences across the community. Systems thinking through causal loop diagram offers a glimpse beyond the spread of COVID-19 to recognise the implications of decisions and actions involving many interconnected factors in such complex situations (Bradley *et al.*, 2020).

Sahin *et al.* (2020) developed a causal loop diagram to identify the interconnectivity between health, economy, society and environment in managing the COVID-19 pandemic. Jackson (2020) used critical systems thinking to understand the complexity of COVID-19 transmission in the UK and argued that effective improvements and interventions are possible only when the complexity is untangled. Hosseini Bamakan and Haddadpoor Jahromi (2021) constructed a causal loop diagram to model how social responsibility plays a significant part in preventing the spread of COVID-19 within the community. With the goal to reduce the transmission risk of COVID-19 for healthcare staff and patients during mass testing in the emergency department, Araz *et al.* (2020) used the systems approach to propose a systematic framework for drive-through COVID-19 testing sites. Phang *et al.* (2021) simulated several scenarios to determine medical staff and patient safety issues in healthcare services when in contact with infectious diseases based on systems thinking.

The systems thinking approach by Diez Roux (2020) affirmed that social distancing and movement restrictions affect the population health beyond COVID-19 and may result in unintended consequences. Sturmberg *et al.* (2022) on the other hand viewed COVID-19 crisis as an opportunity to redesign the health policy using systems thinking in that the dynamics of infectious disease, health system and crisis management are considered. Adamu *et al.* (2020)

developed a causal loop diagram to illustrate how COVID-19 and related control strategies adversely affect the timely childhood immunization in African countries.

Systems thinking approaches have been applied to address issues related to COVID-19. High emphasis is given to identifying and understanding the complexity of COVID-19 from different perspectives. On intervention strategies, the recent studies tend to either focus on preventive measures (Bradley *et al.*, 2020; Diez Roux, 2020; Sahin *et al.*, 2020) or control measures (Gonella *et al.*, 2020). The current study aims to fill this research gap not only by untangling the complexity but also identifying the interaction of different intervention strategies implemented in Malaysia to reduce the spread of COVID-19.

Research methods

This study was conducted during the peak of COVID-19 infection in Malaysia from May to September 2021. Considering the impact and threat of COVID-19 outbreak in Malaysia, the National Security Council (Majlis Keselamatan Negara) was instructed on March 2020 by the then Prime Minister, Tan Sri Muhyiddin Yassin, to manage, coordinate and devise policies to curb the number of COVID-19 cases (Rafidah and Ahmad Suhael, 2020). All endorsed national strategies to control COVID-19 infection in Malaysia were announced and made available through the National Security Council's official website and social media.

Since March 2020, information related to COVID-19 in Malaysia has been updated daily by the Ministry of Health through its official website and social media. On September 2021, the Ministry of Health launched a new COVID-19 data website with comprehensive infographic tracking the daily administered vaccine, daily active COVID-19 cases along with the percentage of active cases on home quarantine, at the Low-Risk Quarantine and Treatment Centre (PKRC), hospitalised and in Intensive Care Units (ICU). Table 1 presents the list of data and information collected for this study.

Systems thinking provides a framework that assists policy makers to make sense of the big picture by understanding the interconnectedness of different parts and how these parts trigger different consequences of decision making, thus giving the policy makers an

Data / Information	*Sources*
Malaysia COVID-19 Standard Operating Procedures	The Ministry of Health's official website on COVID-19: https://covid-19.moh.gov.my/ The National Security official website: https://www.mkn.gov.my/web/ms/sop-perintah-kawalan-pergerakan/
Announcement and Guidelines of Intervention Strategies in Malaysia	The Ministry of Health's official website on COVID-19: https://covid-19.moh.gov.my/
Data related to COVID-19 (Number of daily infected cases, exposed, quarantined, death and recovered; Update on new COVID-19 clusters and new COVID-19 variants, etc.) in Malaysia	The Ministry of Health's official website on COVID-19 (Prior to September 2021): https://covid-19.moh.gov.my/ The Ministry of Health's official website on COVID-19 (September 2021 onwards): https://covidnow.moh.gov.my/
Information on the Perception and Impact of Implemented Intervention Strategies in Malaysia	Local and international newspapers official websites; General public's comments over social medias on the implemented intervention strategies.
Worldwide data and information on COVID-19	WHO COVID-19 Dashboard: https://covid19.who.int/ WHO COVID-19 Resources: https://www.who.int/emergencies/diseases/novel-coronavirus-2019

Source: By authors

Table 1.
Source of data and information used for the construction of the causal loop diagram

opportunity to devise effective strategies to reduce unintended consequences (Bureš, 2017; Luke and Stamatakis, 2012). The application of systems thinking leads to the development of comprehensive models (Bureš, 2017) to understand the interrelations and interconnectedness of different parts in a system. Following the COVID-19 outbreak, other studies that use systems thinking emerged, demonstrating the potential of this method in tackling the labyrinthine interrelations triggered by the pandemic (Haley *et al.*, 2021; Zięba, 2021). Systems thinking also provides stakeholders with a better understanding of the implications of different responses by looking beyond the chain of infection in designing the best approach to battle against COVID-19 infection (Bradley *et al.*, 2020).

The essence of systems thinking is tapped by developing a causal loop diagram. Causal loop diagrams serve as visual tools capable of representing the dynamic complexity in a system (Bogdewic and Ramaswamy, 2021). After gathering the necessary information, a causal loop diagram is developed by recognising the feedback loops and causal-and-effect relationship among variables. The causal loop diagram involves interpreting important or meaningful variables and how these variables form feedback that influences the system (Linnéusson *et al.*, 2022).

The process of synthesising the causal loop diagram is guided by the outcomes from action and reaction loops whilst identifying potential unintended consequences (Dianat *et al.*, 2021). A causal loop diagram comprises variables connected by arrows representing the causal influences where these linked variables will form feedback loops. The feedback loops consist of interconnected balancing loops (represented by B) and reinforcing loops (represented by R). The reinforcing loop indicates that if the cause increases, the effect increases; whereas if the cause decreases, the effect decreases as well; on the other hand, the balancing loop signifies that if the cause increases, the effect deceases; and if the cause decreases, the effect increases (Sterman, 2000).

The developed causal loop diagram is then validated by subject matter experts. In this study, four subject matter experts were invited to review, comment and validate the developed causal loop diagram in a focus group discussion. The subject matter experts consist of expert panels with knowledge and experience working with COVID-19 pandemic in Malaysia. Table 2 depicts the profile of the expert panels. The names of the expert panels were concealed for anonymity.

The developed causal loop diagram is then refined and improved on the bases of the comments and suggestions gathered from the expert panels.

Results and discussion

The developed causal loop diagram on intervention strategies implemented in Malaysia to battle against the spread of COVID-19 had brought forth a total of six reinforcing loops and eight balancing loops. This paper presents the intervention strategies in two parts. The first

Subject Matter Experts	*Profile*
Expert Panel 1	Medical Doctor, Centre for Communicable Diseases Epidemiology Research, Institute for Public Health, National Institutes of Health
Expert Panel 2	Medical Doctor, Ministry of Health, Malaysia
Expert Panel 3	Environmental Health Researcher, Centre for Communicable Diseases Epidemiology Research, Institute for Public Health, National Institutes of Health
Expert Panel 4	Environmental Health, Inspectorate and State Legislation Officer, Kuala Lumpur and Putrajaya Health Department

Source: By authors

Table 2. Profile of subject matter experts

part focuses on the implemented strategies to control the spread of COVID-19, i.e., after the population is exposed to the virus. The second part concentrates on the implemented strategies to prevent the spread of COVID-19, i.e., before the population is exposed to the virus.

Intervention strategies to control the spread of COVID-19

Figure 2 describes the narrative of balancing and reinforcing feedback loops corresponding to strategies implemented to curb the spread of COVID-19 after the population is exposed to the virus. A total of five different strategies are implemented to control the infected population from experiencing further snowballing of the spread. These strategies are tracking, screening and testing, home quarantine for the exposed, home quarantine for the infected, Low-Risk Quarantine and Treatment Centres (PKRC) Quarantine for the infected, and isolating patients in the hospitals. How these strategies responded, interacted with other implemented strategies and ultimately reduced or increased the transmission of COVID-19 will be explained through the developed balancing and reinforcing feedback loops.

The first loop in Figure 2 is R1 reinforcing loop, which explains that an increase in the spread of COVID-19 increases the number of people exposed (exposed population) to the virus. Similarly, as depicted in R2 reinforcing loop, if the number of people exposed to the COVID-19 increases, it will increase the number of people infected by COVID-19; the spread exacerbates other COVID-19 clusters which in turn expose more people to the risk of contracting COVID-19 (R3 reinforcing loop).

The B1 balancing loop shows that by rigorously conducting tracking, screening and testing the exposed population, the spread of COVID-19 can be reduced. Likewise, as the number of exposed populations being tracked, screened and tested increases, more exposed populations will be put under home quarantine, which will further reduce the spread of COVID-19 (B2 balancing loop). In Malaysia, COVID-19 cases are classified according to five

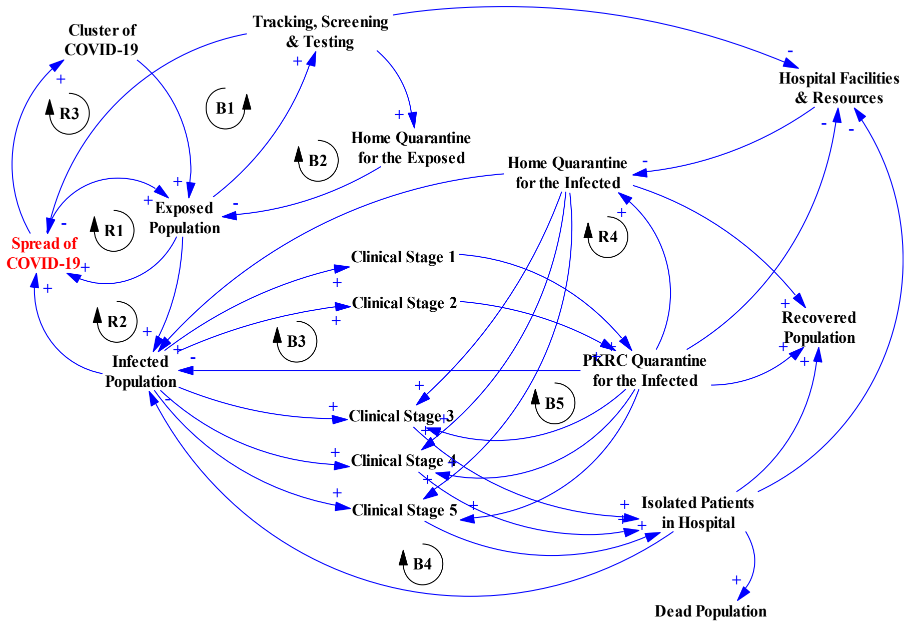

Figure 2.
Causal Loop Diagram of strategies implemented to control COVID-19
Source: By authors

different categories, depending on the severity of the patients (MOH, 2020) as per the description in Table 3.

As the number of exposed population increases, the number of infected population grows. The infected population, depending on their severity, are quarantined and isolated. Infected patients who are in clinical stages 1 and 2 are quarantined at the Low-Risk Quarantine and Treatment Centres (PKRC). As more clinical stages 1 and 2 patients are quarantined, the infected population will be reduced along with the spread of COVID-19 (B3 balancing loop). However, an increase in clinical stages 1 and 2 infected patients being quarantined at the PKRC causes two ripple effects.

Firstly, the high number of patients quarantined at the PKRC reduces the capacity (in terms of bed capacity, facilities, staff and medical officers). When the PKRC is crowded and unable to accommodate more patients, the clinical stages 1 and 2 infected patients will be diverted to home quarantine. The interviewed expert panels revealed that home quarantine for infected patients is ineffective in restraining the spread of COVID-19. Infected patients who underwent home quarantine risk, were spreading the virus to their household members due to sharing of toilets, other necessities and poor ventilation. As depicted in reinforcing loop R4, an increase in home quarantine for the infected raises the number of infected population and further increases the spread of COVID-19.

By contrast, as illustrated by balancing loop B5, with more clinical stages 1 and 2 infected patients being quarantined at the PKRC, these patients tend to become critically ill over time and then be re-categorised as clinical stages 3, 4 or 5. The increase in clinical stages 3, 4 and 5, infected patients will increase the number of isolated patients at the hospital and will collectively reduce the number of infected population and the spread of COVID-19. The last balancing loop B4 explains that with an infected population growing, the number of infected patients falling under clinical stages 3, 4 and 5 increases. Consequently, it escalates the number of patients to be isolated and be given intensive treatment at the hospital. This procedure will then help prevent the further spread of COVID-19.

Apart from the balancing and reinforcing feedback loops, several auxiliary variables are also being identified as shown in Figure 2. Hospital facilities and resources play an important role in strategies such as tracking, screening, and testing; PKRC quarantine for the infected and isolating critical patients in the hospital. Without adequate medical equipment and manpower, all these three strategies will fail to outpace the rate of COVID-19 transmission in Malaysia. Therefore, if the number of exposed and infected cases increases beyond the capacity of hospital facilities and resources, the implemented strategies to control the spread of COVID-19 will collapse. Table 4 summarises the narrative of all balancing and reinforcing feedback loops that corresponded to the strategies implemented to control COVID-19 transmission.

Intervention strategies to prevent the spread of COVID-19

Figure 3 sets forth the balancing and reinforcing feedback loops of strategies implemented to restrain the spread of COVID-19 in Malaysia. The major strategies imposed to prevent the

Clinical Stage	*Indicators*
Clinical Stage 1	Asymptomatic
Clinical Stage 2	Symptomatic, No Pneumonia
Clinical Stage 3	Symptomatic, Pneumonia
Clinical Stage 4	Symptomatic, Pneumonia, Requiring Supplemental Oxygen
Clinical Stage 5	Critically Ill with Multi-Organ Involvement

Source: MOH (2020)

Table 3. Clinical stage of COVID-19 infection in Malaysia

Feedback Loop	Representation
R1	Increase Spread of COVID-19 > Increase Exposed Population > Increase Spread of COVID-19
R2	Increase Spread of COVID-19 > Increase Exposed Population > Increase Infected Population > Increase Spread of COVID-19
R3	Increase Spread of COVID-19 > Increase Clusters of COVID-19 > Increase Spread of COVID-19
R4	Increase Spread of COVID-19 > Increase Exposed Population > Increase Infected Population > Increase Clinical Stage 1/Clinical Stage 2 > Increase PKRC Quarantine for the Infected > Increase Home Quarantine for the Infected > Increase Infected Population > Increase Spread of COVID-19
B1	Increase Spread of COVID-19 > Increase Exposed Population > Increase Tracking, Screening & Testing > Reduce Spread of COVID-19
B2	Increase Spread of COVID-19 > Increase Exposed Population > Increase Tracking, Screening & Testing > Increase Home Quarantine for the Exposed > Reduce Exposed Population > Reduce Spread of COVID-19
B3	Increase Spread of COVID-19 > Increase Exposed Population > Increase Infected Population > Increase Clinical Stage 1/Clinical Stage 2 > Increase PKRC Quarantine for the Infected > Reduce Infected Population > Reduce the Spread of COVID-19
B4	Increase Spread of COVID-19 > Increase Exposed Population > Increase Infected Population > Increase Clinical Stage 3/Clinical Stage 4/Clinical Stage 5 > Increase Isolated Patients in Hospital > Reduce Infected Population > Reduce the Spread of COVID-19
B5	Increase Spread of COVID-19 > Increase Exposed Population > Increase Infected Population > Increase Clinical Stage 1/Clinical Stage 2 > Increase PKRC Quarantine for the Infected > Increase Clinical Stage 3/Clinical Stage 4/Clinical Stage 5 > Increase Isolated Patients in Hospital > Reduce Infected Population > Reduce the Spread of COVID-19

Source: By authors

Table 4.
Summary of feedback loops that depict strategies implemented to control the spread of COVID-19

transmission of COVID-19 are the enforcement of standard operating procedures (SOPs), movement restriction and nationwide vaccination programme. Except for the vaccination programme, which is currently ongoing, the other two strategies were implemented during the period of Movement Control Orders (MCOs). The comprehensive SOPs include guidelines on general health protocol for businesses that serve the public, business and service sectors that allow them to operate religious activities, sports and recreation activities, and many other activities (MOH, 2021). As for the imposed movement restriction during MCO, interstate travelling within Malaysia was not allowed, and the allowable travelling distance was within 10-km radius from the point of residence.

Looking at the narrative of Figure 3, balancing loop B6 reveals that if the spread of COVID-19 increases, the movement restriction will be tighter and therefore reduce human mobility and interaction which will then reduce the spread of COVID-19. Balancing loop B7 explains a similar scenario that when human mobility and interaction are reduced, the number of SOP violations decreases and tends to lower the spread of COVID-19. When the movement restrictions are tightened, pandemic fatigue grows among the public. Pandemic fatigue gradually happens when the public are exhausted with all the pandemic measures and become less likely to follow the guidelines due to emotions, experiences and perceptions (WHO, 2020b). The rise of pandemic fatigue triggers the concern of mental health issues and suicidal cases which hence increase the pressure to relax movement restrictions.

The interconnectedness between pandemic fatigue and movement restrictions are illustrated by balancing loop B8. Reinforcing loop R5 shows that the escalation of pandemic fatigue increases SOP violations among the public and increases the spread of COVID-19. Disruption in life and livelihood triggers pandemic fatigue as elucidated in reinforcing loop R6. Prolonged movement restriction has an adverse impact on the economy and affects livelihood as people are losing their jobs due to downsizing and closure of businesses.

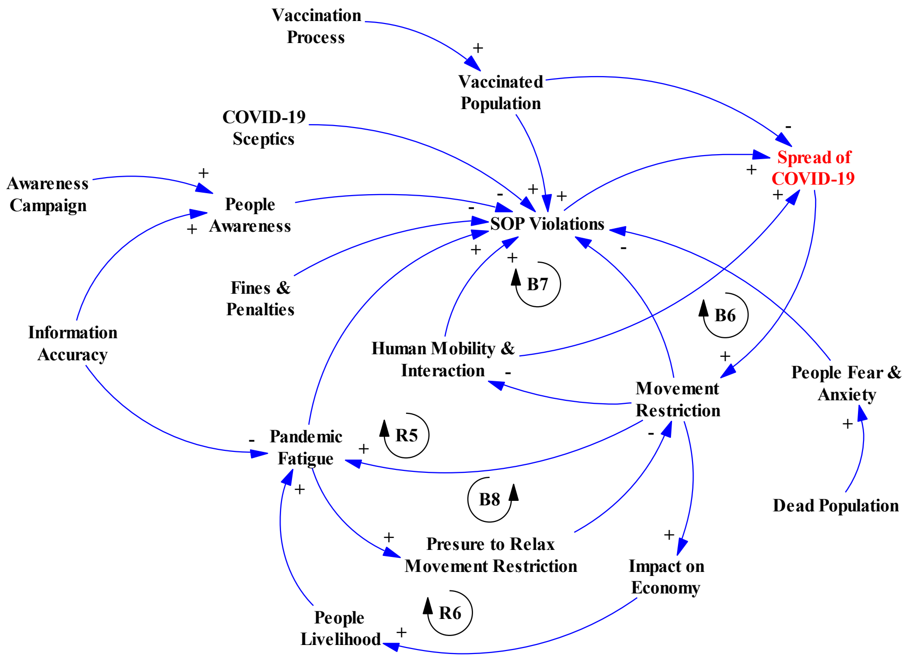

Figure 3.
Causal Loop Diagram of strategies implemented to prevent the spread of COVID-19
Source: By authors

A few auxiliary variables are also identified in Figure 3 as strategies that are capable of either increasing or decreasing the number of SOP violations which will have a direct influence on the spread of COVID-19. The first strategy is the vaccination programme whereby expediting the vaccination process will gradually increase the inoculated population. However, our expert panels revealed that people who are already vaccinated tend to violate the SOP and consequently spread the virus (although once infected, their severity is largely reduced than those who are yet to receive the first dose of vaccination).

On a more positive side, by vaccinating the majority of the population, the spread of COVID-19 can be reduced (i.e., if they strictly adhere to the SOPs). Imposing stricter fines and penalties, increasing people's awareness through accurate and genuine information and awareness campaigns can evidently reduce SOP violations. Misinformation and fake claims spread rapidly on social media throughout the period of the COVID-19 pandemic, causing confusion to the general public and perturbed pandemic fatigue. The fear and anxiety over the high number of COVID-19 cases and death forced people to adhere to the SOP regulations. COVID-19 'sceptics' also contributed to the rise in SOP violations, thereby increasing the spread of COVID-19. Table 5 shows the summary of feedback loops that explain the strategies implemented to prevent the spread of COVID-19.

Merging the implemented intervention strategies

Figure 4 illustrates the combined causal loops of Figures 2 and 3. By combining these feedback loops, the representation in Figure 4 shows a coherent view on how each implemented strategy affects other initiatives and collectively as a whole contributes to the control and prevention of the spread of COVID-19. With the spread of COVID-19 acting as the 'nexus', the loops on the right (in Figure 4) depict intervention strategies implemented to respond or curb the ongoing spread of COVID-19, whilst the loops on the left side of the nexus focus on the intervention strategies implemented to prevent the transmission of COVID-19.

Evidently, intervention strategies from both sides (left and right) of the causal loop diagram need to be in a state of equilibrium to successfully flatten the curve of COVID-19 cases. Focusing more on strategies to control the spread (right) will end up exhausting the hospital facilities, medical resources and not to say burning out medical officers as the number of transmissions escalates without effective prevention measures. This scenario will result in a high number of deaths (in COVID-19 patients) and COVID-19-linked deaths (e.g., could not be admitted due to depleted medical resources). As per Figure 4, a high number of deaths prevalently will create anxiety and fear among the public which will exacerbate pandemic fatigue and other psychological issues among the people.

At the other end of the spectrum, focusing heavily on intervention strategies to prevent the spread (left) but neglecting intervention strategies to control the spread (right) will risk those who are exposed and infected with COVID-19 not having proper isolation, medication and treatment. Undoubtedly, it severely aggravates the spread of COVID-19. Therefore, excessive focus on strategies either to control or only to prevent the transmission of COVID-19 will result in potential unintended consequences that will hinder the main purpose which is to reduce the spread of COVID-19.

Conclusion

This paper aims to identify the interaction of different intervention strategies implemented to flatten the curve of COVID-19 cases in Malaysia. A causal loop diagram was developed to capture the cause, effect and relationship among these implemented strategies. The developed feedback loops enabled visualisation of how each implemented strategies interacted with each other and then collectively decreased or increased the spread of COVID-19 in Malaysia. The causal loop diagram evoked an important message where a necessity arises not only to control the spread of COVID-19 but also to prevent the transmission of the virus. These two sets of strategies (to control and to prevent) need to be in a state of equilibrium to demonstrate the reduction in the spike of COVID-19 cases. Focusing only on one set of strategies will throw off the balance and rapidly escalate the spread of COVID-19.

In the early stage of the pandemic, the Malaysian government emphasised movement restriction, a strategy to prevent the spread of COVID-19 and isolating infectious patients in hospitals to control the infected population. A status quo was achieved, but eventually, with prolonged confinement, pandemic fatigue occurs, resulted in more SOP violations and the continuous spread of COVID-19 within the community. This was alarming as the hospitals could not cope with the sudden spike in COVID-19 cases. With an effort to reinforce the control strategies, the Malaysian government introduced mass quarantine centres, mass

Table 5. Summary of feedback loops that illustrate strategies implemented to prevent the spread of COVID-19

Feedback Loop	*Representation*
R5	Increase Spread of COVID-19 > Increase Movement Restriction > Increase Pandemic Fatigue > Increase SOP Violation > Increase Spread of COVID-19
R6	Increase Spread of COVID-19 > Increase Movement Restriction > Increase Impact on the Economy > Increase Impact on People Livelihood > Increase Pandemic Fatigue > Increase SOP Violation > Increase the Spread of COVID-19
B6	Increase Spread of COVID-19 > Increase Movement Restriction > Reduce Human Mobility & Interaction > Reduce Spread of COVID-19
B7	Increase Spread of COVID-19 > Increase Movement Restriction > Reduce Human Mobility & Interaction > Decrease SOP Violation > Reduce Spread of COVID-19
B8	Increase Movement Restriction > Increase Pandemic Fatigue > Increase Pressure to Relax Movement Restriction > Reduce Movement Restriction

Source: By authors

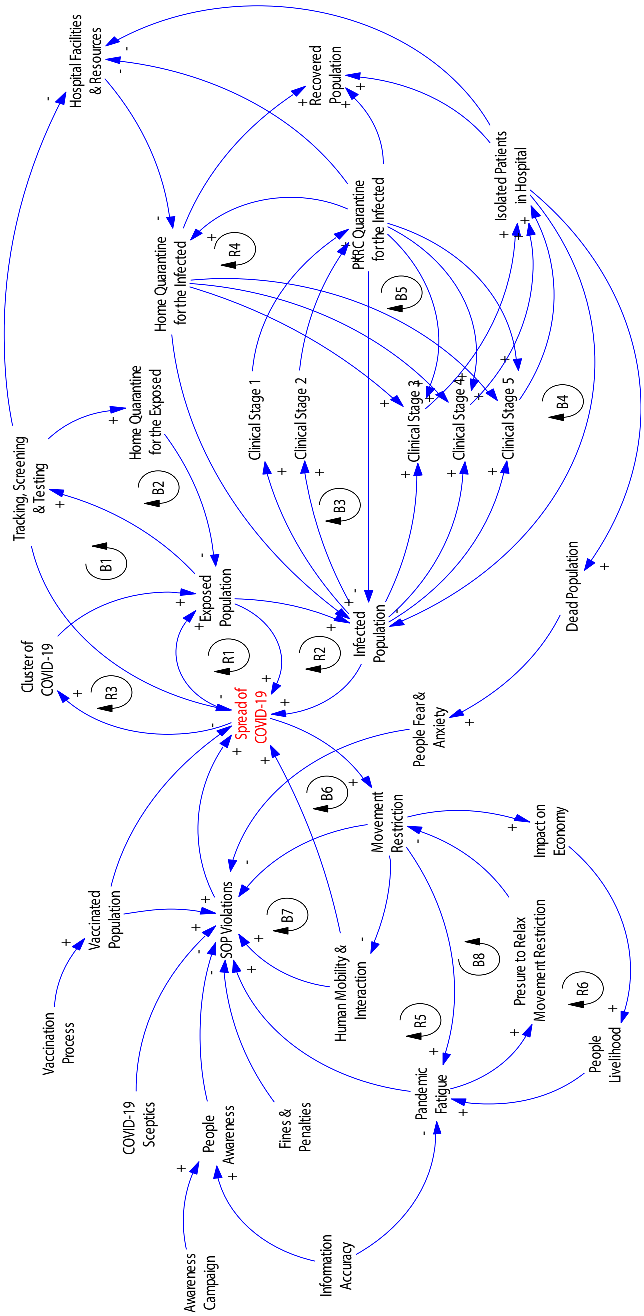

Figure 4.
Complete Causal Loop Diagram on implemented strategies to control and prevent COVID-19 infection
Source: By authors

tracking, screening and testing, and home quarantine. As Malaysia needs to reopen its border, in order to prevent a catastrophic COVID-19 surge, mass vaccination programme is introduced. Therefore, it is evident that a balance of control and prevention strategies are crucial to break the chain of COVID-19.

The causal loop diagram developed by Diez Roux (2020) and Bogdewic and Ramaswamy (2021) support that preventive measures such as movement restriction and economy shutdown reduce the spread of COVID-19 but adversely affect people's survival and mental health. Similar to Hosseini Bamakan and Haddadpoor Jahromi (2021) and Bradley *et al.* (2020), this study agrees that raising public awareness and concern about COVID-19 serves as an effective preventive measure to battle against COVID-19 transmission. Cultivating social responsibility within the community reduces the rapid spread of COVID-19 and avoids the collapse of the healthcare system (burden on the control strategies). In contrast to Diez Roux (2020) who emphasised that government action is critical to protect the public health, this study puts forward the need for the responsibility to be shared by the community. In the long run, individuals' responsibilities will be more effective in shielding the community from the threat of COVID-19 infection as the nation moves into the endemic phase.

For future research, this study can be replicable to any viral outbreaks of diseases that pose threats to the community. In addition, whilst this study focused on different intervention strategies enforced during the response phase of COVID-19 outbreak, future studies can explore the interaction among strategies and potential strategies implemented in other pandemic phases such as mitigation, preparedness and recovery. Overall, the developed causal loop diagram provides policy makers a clearer understanding about the interaction and effect of different implemented intervention strategies. It will result in more informed decisions during the process of crafting effective strategies to control COVID-19 infection.

By the end of September 2021, the rate of COVID-19 infection in Malaysia began slowing down, thanks to the massive outreach vaccination programme. As of mid-October 2021, all movement restrictions were lifted, interstate and international travels (in transition) were eased and all economic sectors were allowed to open with strict standard operating procedures. As Malaysia is transitioning to the epidemic phase, living with COVID-19 is the new normal. The battle against COVID-19 shows no guarantee of approaching endgame. Anything may trigger the surge of cases again, and Malaysia may be unable to endure another round of nationwide lockdown. Therefore, more effective strategies need to be crafted, especially strategies that can protect the life of the people against COVID-19 without compromising their livelihood. This developed causal loop diagram provides policy makers a gateway to recognise the merits and pitfalls of all previously implemented intervention strategies with the aim of devising more effective intervention strategies to further defuse COVID-19 infection and prepare the nation towards recovery.

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