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Chapter

Human Cultural Dimensions and Behavior during COVID-19 Can Lead to Policy Resistance and Economic Losses: A Perspective from Game Theory Analysis

Tamer Oraby, Michael G. Tyshenko and Samit Bhattacharyya

Abstract

The recent COVID-19 pandemic has caused significant societal impacts. Besides loss of life there were large additional costs incurred by every country including the treatment of patients and costs to implement response plans. The pandemic resulted in major economic disruptions and stalled growth worldwide due to travel bans, lockdowns, social distancing, and non-essential business closures. Public health officials in almost every country implemented and encouraged Nonpharmaceutical Interventions (NPIs) such as contact tracing, social distancing, masks, and isolation. Human behavioral decision-making concerning social isolation was a major hindrance to the success in curbing the pandemic worldwide. In many developing countries individuals' choices were motivated by the competing risk of losing jobs, and daily income. In this chapter we focus on human behavior concerning social isolation in the context of decision-making during the pandemic. We developed a conceptual framework and deterministic model that integrated evolutionary game theory within our disease transmission model. We illustrate scenarios numerically simulating the model. This study highlights the idea that human behavior is an important component in successful disease control strategies. Economic resilience, especially in low-income countries, can improve public understanding and uptake of NPIs.

Keywords: COVID-19, nonpharmaceutical interventions, cultural dimensions, human behavior, policy resistance, communication, mathematical model, game theory

1. Introduction

A month before the Chinese Spring Festival, the Chinese government reported multiple cases of pneumonia of unknown etiology in Wuhan, Hubei Province, China in December 2019. On January 20, 2020, there were 282 confirmed cases in and around Wuhan, of which 51 were severely ill, 12 were in a critical condition and six deaths as reported to the World Health Organization (WHO) [1]. Three days later public health officials in China implemented strict control measures in Wuhan with a complete lockdown of the population that lasted 76-days. Wuhan is the largest city in Hubei province with a population of over 14 million people [2].

A week later on January 30 2020, WHO declared this outbreak a public health emergency of international concern (PHEIC). The outbreak was caused by a novel coronavirus, SARS-CoV-2, and the disease was named COVID-19 [3, 4]. Since then, almost all countries started implementing several Nonpharmaceutical Interventions (NPIs) such as contact tracing, social distancing, mask wearing, self- isolation, school closures, business closures and countrywide lockdowns at different levels of strictness to stop the spread of the disease.

At the beginning of a pandemic several NPIs can be implemented by public health officials as a way to slow disease transmission until an effective vaccine or antiviral treatment becomes available. Implemented public health measures place restrictions on individuals and understanding how individuals respond and whether they are likely to comply or break new rules is extremely important. Measures can theoretically greatly influence and reduce the spread of the infection. However, human choice and self-interest chosen over altruism, among many other factors, can hamper NPI effectiveness and disease control efforts.

For example, lockdowns and self-isolation (self-quarantine) can be highly effective in reducing transmission but can result in population-wide socioeconomic and psychosocial impacts [5]. Adverse effects from extended isolation have been reported in a number of groups including children and adolescents [6, 7], immigrant workers [8, 9] and adults [10, 11]. Children experienced changes to their eating habits, sleep disturbances, depression and symptoms of anxiety [12–14]. Adults reported increased mental health issues, anxiety, stigma, depression, alcohol related harm, and domestic violence [10, 11, 15].

There are a number of demographics, social and psychological factors underpinning engagement with quarantine, lockdown, and compliance with public health directives regarding personal protective behaviors. Factors include perception of susceptibility to the infection, severity of the infection, perception of the effectiveness of ongoing public health measures, and their ability to conduct the activity safely (self-efficacy) [16]. One of the main reasons identified in research literature for non-adherence to quarantine and self-isolation is the perception of lower risk for the disease or having fewer risk factors [17]. Psychological fatigue is also suggested as a possible reason for NPI non-compliance [18, 19].

While cultural and social factors might be challenged by fear [20], the economic difficulty faced by some groups and especially minorities in some places, plays a role in human choice. This might partly explain the disproportionate COVID-19 incidence and mortality faced by minorities in the US, Australia, Canada, and the UK [21–24]. Similarly, migrant workers in low-income countries are also an economically vulnerable population group [25]. Thus, cultural dimensions (see **Figure 1**) can greatly affect uptake and adherence to NPIs ([26–30] as well as disease transmission and mortality [31].

Initial and ongoing compliance by individuals is promoted by the existing level of infrastructure, resources, stockpiles, inter-pandemic planning, communication efforts from authoritative sources and the country's capacity. People afraid of contracting a viral infection will adhere to the best hygienic procedures, use masks, practice social distancing and avoid crowded places. While such measures act to delay the spread of viral diseases, like COVID-19, it will not completely protect the population. Public health directives that seek to reduce population-level risk factors and disease transmission are closely aligned with the idea of each individual practicing the best hygienic procedures, collectively, to achieve high compliance.

Indeed, economic growth and capacity as measured by gross domestic product (GDP) provides a measure of the pre-existing infrastructure to maintain and enforce law and order, regulate economic activity, and provide public goods during a protracted pandemic wave [32]. Many countries in less-developed parts of the
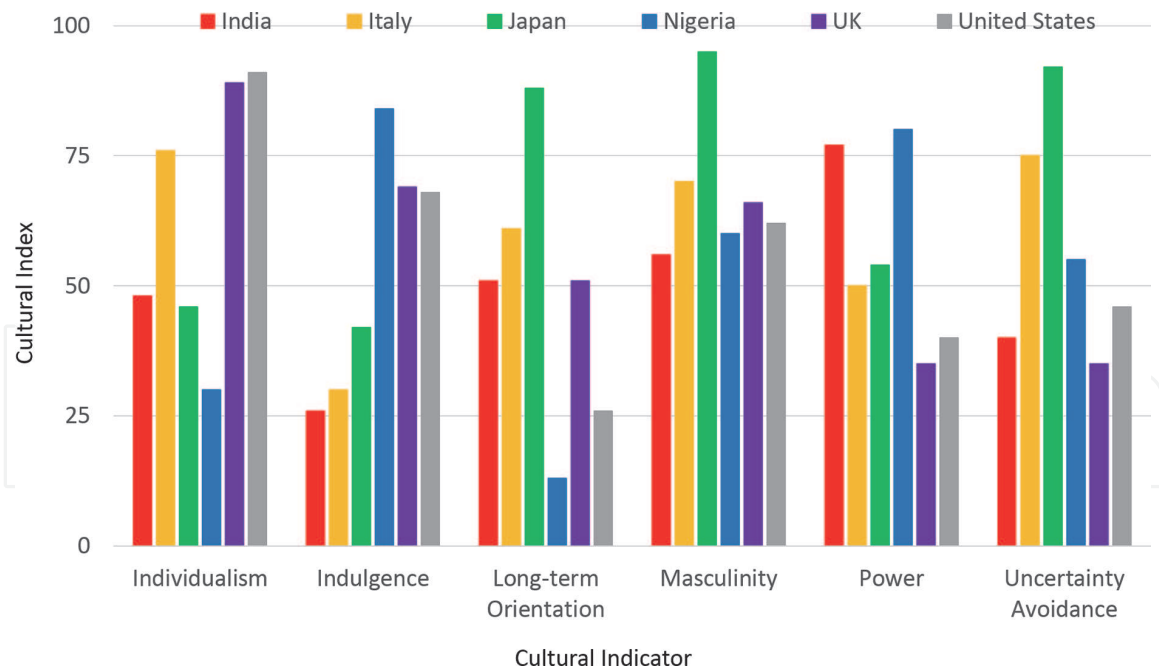
Figure 1.
A comparison of six cultural dimensions among six countries. For discussion see the text. (data source: https://www.hofstede-insights.com/).

world lack this capacity and are more vulnerable to system shocks like pandemics that disrupt economic growth and reduce GDP (**Figure 2**) [33].

Two decades ago, British psychologist James Reason introduced the Swiss Cheese Model to describe how failures in complex systems occur [34]. In his model he suggested that multiple defenses can be in place, whose function is to protect individuals from hazards, but these can possess inherent weaknesses. Multiple safeguards or barriers are like slices of Swiss cheese, having many transient holes. Having holes in any one "slice" does not normally cause a bad outcome. If the holes in many layers line up so they permit a trajectory of accident opportunity through the layers, then it allows for hazard exposure resulting in victims. The holes in the established defenses arise for two reasons: active failures and latent conditions. Nearly all adverse events involve a combination of these two sets of factors.

Google mobility data trends reported from mid-February to mid-December 2020 provide insight into the conditions and active failures during the COVID-19
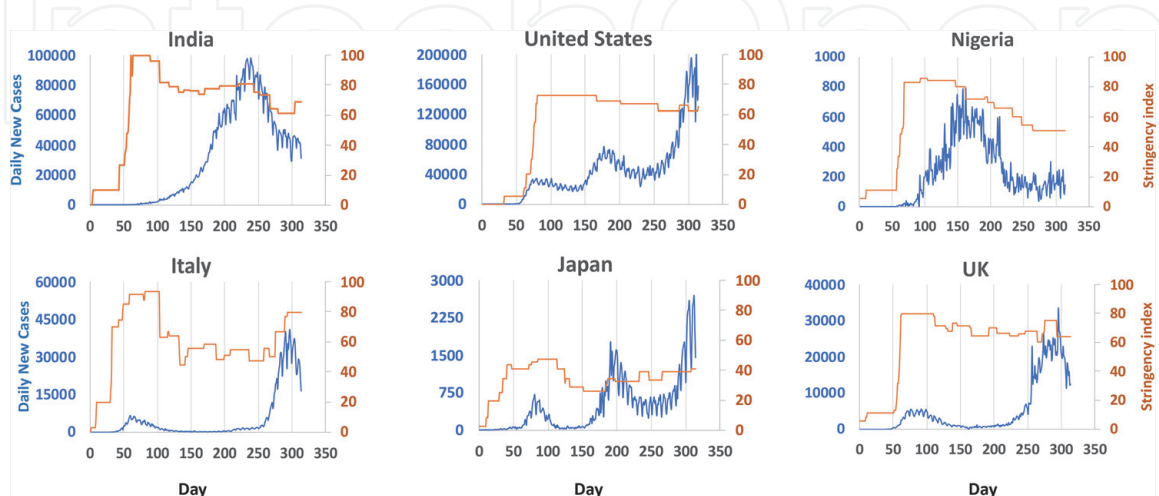

Figure 2.
Daily new cases and lockdown stringency index for the six countries. The day 'o' starts with the date January 22, 2020. The percentage reduction in the growth rates of GDP in 2020 due to COVID are as follows: India −10.29%, US -5.91%, Nigeria −3.41%, Italy −10.6%, Japan −5.27%, UK -10.2%. Data source: Our world in data, https://ourworldindata.org/covid-mobility-trends, and https://www.statista.com.
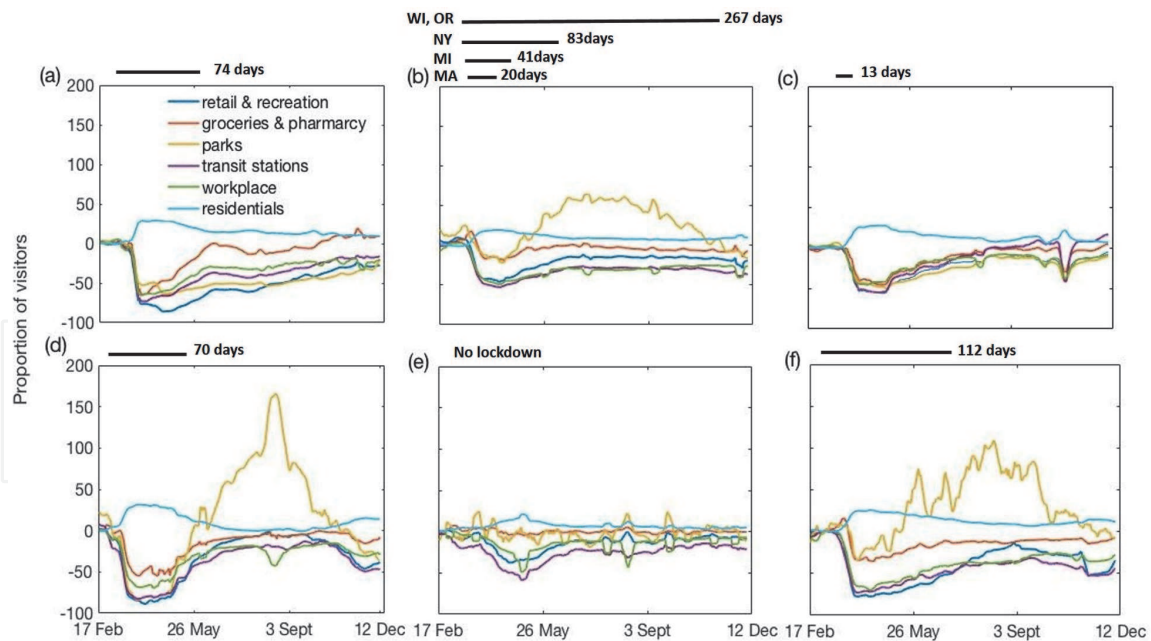
Figure 3.
Google mobility trends: Movement of people during COVID-19 lockdown period: (a) India, (b) United States (MA-Massachusetts, MI-Michigan, NY-New York, and WI, OR - Wisconsin, Oregon), (c) Nigeria, (d) Italy, (e) Japan, and (f) UK. For discussion, see the text. (data source: Our world in data, https://ourworldindata.org/covid-mobility-trends).

pandemic stemming from changes in human behaviors. In India (**Figure 3a**) there was good compliance at the beginning of the 74-day lockdown that began on March 25, 2020. However, as the lockdown progressed movement in all tracked mobility categories slowly increased until the end of lockdown. Retail and recreation showed an increase at the beginning of the lockdown as some people ignored social isolation to maintain their livelihoods.

Unlike India, the United States (**Figure 3b**) did not implement a nationwide lockdown, instead many states put in place lockdowns of various lengths ranging from 20–267 days (many states began lockdowns during the third week of March 2020). Compliance remained high for the first month and slowly mobility in all categories increased. Notably, mobility to parks and other open spaces increased significantly as shorter lockdowns in some states ended as spring weather arrived.

Nigeria (**Figure 3c**) imposed a 13-day lockdown on March 30 2020 with good compliance. Once the short lockdown ended mobility trended back upwards towards normal levels over the next two months.

Italy (**Figure 3d**) implemented a 70-day nationwide lockdown that began on March 9 2020 after large clusters of cases were reported in Northern regions of the country. Compliance was good with decreased mobility in all categories except visits to parks and outside spaces.

Japan (**Figure 3e**) was one of the few countries that did not use a lockdown strategy, mobility decreased to transit stations, retail businesses and workplaces as people followed government guidance and avoided hotspot areas and mass gatherings.

The UK (**Figure 3f**) used a 112-day nationwide lockdown that began on March 23, 2020 with good compliance during the first month then mobility increased in all categories. Changes in mobility were similar to what was observed in the United States and Italy. People in the UK spent increasing amounts of time outdoors and in parks during the lockdown [35].

The Swiss Cheese Model can be applied to pandemic defenses or safeguards showing that there are two levels protecting people: personal and interpersonal safeguards. When applying the Swiss Cheese Model to COVID-19 the pandemic barriers which can fail are the early NPIs such as social distancing, self-isolation and

lockdowns. For the model we group these NPIs collectively as "social isolation" barriers. In this chapter, we focus on human behavior of social isolation decision-making during the pandemic and its impact on socio-economic growth. Integrating evolutionary game theory, economic growth model and a deterministic disease transmission model, we develop a conceptual framework to analyze the situation using a Swiss Cheese Model approach. We illustrate the main scenario of social isolation versus no social isolation and its effects on growth by numerically simulating the model.

2. Model and methods

We use a deterministic model of ordinary differential equations (ODE):

$$\frac{dS}{dt} = -\beta(1-x)(A+I)\,S \tag{1}$$

$$\frac{dE}{dt} = \beta(1-x)(A+I)\,S - \alpha E \tag{2}$$

$$\frac{dA}{dt} = \alpha(1-p)E - \mu_A A \tag{3}$$

$$\frac{dI}{dt} = \alpha p E - \mu_I I - \mu_H I - \mu_D I \tag{4}$$

$$\frac{dH}{dt} = \mu_H\,I - \mu_R\,H - \mu_D\,H \tag{5}$$

$$\frac{dD}{dt} = \mu_D\,I + \mu_D\,H \tag{6}$$

$$\frac{dR}{dt} = \mu_A A + \mu_I\,I + \mu_R\,H \tag{7}$$

$$\frac{dx}{dt} = rx(1-x)(c_1 I + c_2 D - c_3(K_0 - k)/K_0)) - \xi\,x \tag{8}$$

$$\frac{dk}{dt} = \sigma\left((S+A+R)((1-x)+qx)\right)^\gamma k^{1-\gamma} - \delta k - c_h H,\, 0 < q < 1. \tag{9}$$

with seven states/compartments: susceptible (S), exposed but not infectious (E), infected but asymptomatic (A), infected and symptomatic (I), isolated or hospitalized (H), dead (D), and recovered (R) (see **Figure 4**). The same letters ($S, E, A, I, H, R,$ and D) are used notations for the variables that represent the proportion of individuals in each compartment. In this model, the effective transmission rate $\beta(1-x)$ is dependent on the proportion practicing social isolation x whose complement modulates the disease transmission rate β. See **Table 1** for definitions of parameters and their values.

We also use a population behavior dynamical Eq. (8) to model the dynamical changes of x in which people abiding to social isolation compare the risks of infection and fear of death to the relative economic loss. They can also break out of isolation after an average of $1/\xi$ days due to fatigue from social isolation. We postulate that the rate of fatigue ξ is dependent on the six cultural dimensions of Hofstede (see **Figure 1**); especially, individualism, long-term orientation, and indulgence. The constants $c_1, c_2,$ and c_3 reflect also perceptions of risk of infection, fear of death and degree of damage due to the relative drop in GDP. Those factors are also related to cultural, social, and economical characteristics of the society. For instance, the perception of risk of infection might be related to uncertainty
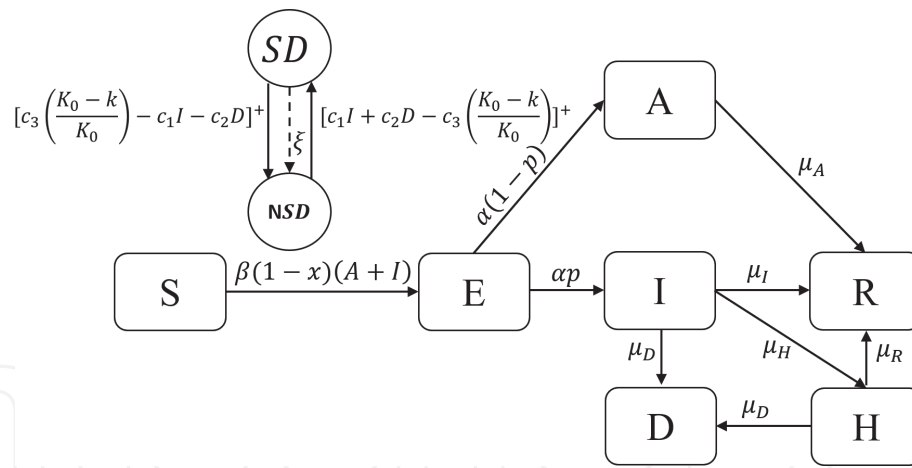
Figure 4.
Schematic illustration of the COVID-19 SEAIHRD model showing the force of infection $\beta(1-x)(A+I)$. Parameters α, μ_A, μ_I, μ_H, μ_R and μ_D are the rates of transition between the compartments. The fraction p is the probability of becoming symptomatic and infectious. The proportion of those who choose to maintain the social isolation is given by x. The pandemic fatigue rate is ξ.

Parameters	Definitions	Values	References
β	Disease transmission rate	0.2306	Calibrated
α	Rate of leaving exposed state	1/7	[36]
p	Probability of becoming symptomatic	0.75	[37]
μ_A	Recovery rate of asymptomatic	1/14	[38]
μ_I	Recovery rate of infectious	1/30	[38]
μ_R	Recovery rate of hospitalized	1/13	Calculated
μ_H	Rate of hospitalization	1/17	Calculated
μ_D	Death rate from disease	0.01	[39]
r	Imitation rate	20	Calibrated
ξ	Pandemic fatigue rate	0–0.5	Calibrated
c_1	Cost of infection	10–1,000	Calibrated
c_2	Fear of death	100–10,000	Calibrated
c_3	Sensitivity to relative economic loss	5–500	Calibrated
c_h	Cost of hospitalization	20,000	Calibrated
σ	Investment rate	0.02/365	Calibrated
γ	Elasticity	0.3	Calibrated
δ	Depreciation rate	0.01/365	Calibrated
K_0	Initial per-capita GDP	55,000	Calibrated
q	Fraction of labor working with social isolation	0.3	Calibrated

Table 1.
Parameters, their definitions, values and references.

avoidance, whereas the economic damage might be related to long-term orientation, masculinity, and socioeconomic status.

The population economic growth/decline is modeled using the Solow economic model of the per-capita GDP ($k = GDP/N$) in \$1000 with Cobb–Douglas functional form of investment and production. We assume an initial per-capita GDP of K_0. The per-capita GDP suffers from lack of labor due to isolation except for a fraction q who are working from home. Also, it decreases due to the hospitalization burden that costs c_h per patient-day.

We use the method of Next-generation matrix [40] to find the basic reproduction number R_0 for the disease model without social isolation (in the beginning of the epidemic). The basic reproduction number is given by

$$R_0 = \beta \left[\frac{1-p}{\mu_A} + \frac{p}{\mu_I + \mu_H + \mu_D} \right]. \tag{10}$$

We use this formula for the basic reproduction number to calibrate some of the disease model's parameters at $R_0 = 2.5$ [41].

3. Results

3.1 Model simulation

We simulated the model using the Runge–Kutta method via the function ode45 in MATLAB. The time unit is day. We assume that the epidemic started with 100
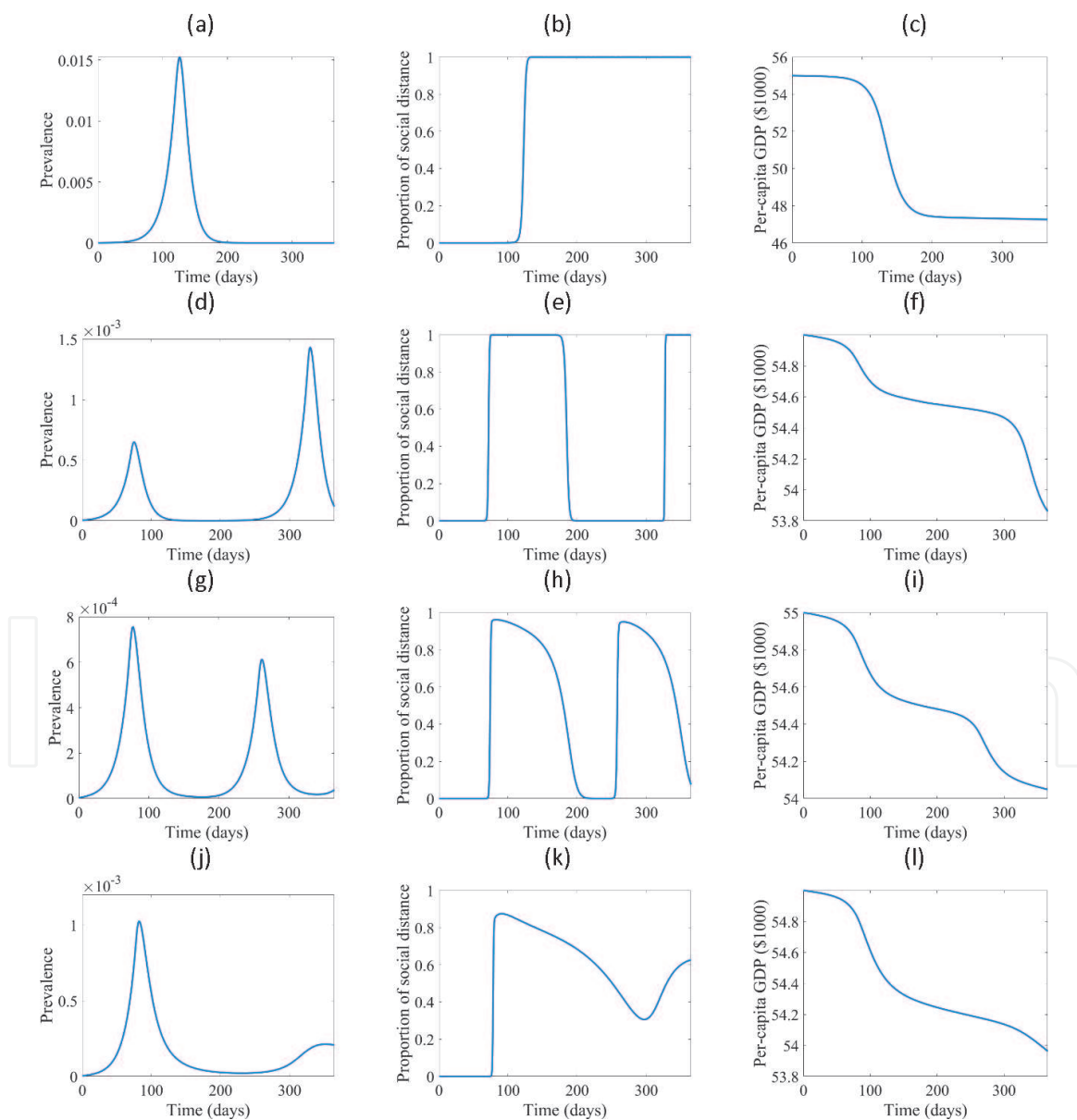

Figure 5.
Simulation of (from left to right) the disease prevalence, the proportion of those practicing social isolation, and per-capita GDP ($1000). The human behavior parameter values are $\xi = 0$, $c_1 = 10$, $c_2 = 100$, and $c_3 = 5$ for figure panels (a-b), $\xi = 0$, $c_1 = 100$, $c_2 = 1000$, and $c_3 = 50$ for figure panels (d-f), $\xi = 0.1$, $c_1 = 100$, $c_2 = 1000$, and $c_3 = 50$ for figure panels (g-i), and $\xi = 0.5$, $c_1 = 100$, $c_2 = 1000$, and $c_3 = 50$ for figure panels (j-l). Prevalence is shown as per 1.

exposed, 50 asymptomatic and 30 infected individuals in a population of size 11,000,000.

Simulations were performed with values given in **Table 1**. In particular, when there is no pandemic fatigue ($\xi = 0$), we found that people can adhere closely to social isolation (policy compliance), resulting in a curb in the disease prevalence, and inflecting and accepting a significant economic burden (at $c_1 = 10$, $c_2 = 100$, and $c_3 = 5$), see **Figure 5 (a)**, **(b)**, and **(c)**. We found also some fluctuations in prevalence occurring from human behavior (at $c_1 = 100$, $c_2 = 1000$, and $c_3 = 50$) (**Figure 5(d)**) and the choice between performing social distance (policy compliance) (**Figure 5(e)**) or ignoring public health directives to maintain economic benefits (i.e. no loss of personal income) (**Figure 5(f)**). The competing interests result in waves of the disease due to changing population level of social isolation versus economic loss from compliance.

In the presence of pandemic fatigue ($\xi = 0.1$), and at the same perceived costs ($c_1 = 100$, $c_2 = 1000$, and $c_3 = 50$), fluctuations continue to occur with a smaller magnitude second wave having a shorter inter-wavelength due to the reduced periods of compliance to social isolation (**Figure 5(g)–(i)**). That is, at a high brunt of economic loss and pandemic fatigue, people might be seen to abandon social isolation which results in a continuation in the spread of the disease, even when fear of death was also high. Increasing the pandemic fatigue rate ($\xi = 0.5$), results in faster decline in policy compliance and a relatively larger epidemic that does not seem to be abated nor fluctuating.

In all of the cases, the per-capita GDP dwindles fast during the waves of the epidemic and slows down as the waves subside, due to the availability of labor and the decreased hospitalizations.

4. Discussion

4.1 Public health guidance and human choice as influencers

Human choice is an important influencer on disease dynamics, and it is dependent on cultural, social and economic factors that might lead to lack of choice. Our model results (**Figure 5**) exhibit that risk of infection, fear of death and the effect of economic loss are important factors as they influence the behaviors of individuals in both lower and higher GDP countries. In lower income countries, an individual's daily wages depend on socioeconomic growth and GDP of the population. The majority of the population in low-income countries survive at or below the poverty line. The World Bank reports there are 33 countries with one-third of the population below the extreme poverty line ($1.90 international dollars/day income) and 69 countries with more than half their population living on less than $5.50 international dollars/day. The definitions of the poverty line vary considerably among nations, however, according to the World bank there are 23 countries with 50% or more of the population living below the nationally designated poverty line deemed appropriate - as defined by its own authorities [42]. The low-income countries include many African countries, Latin American countries (Guatemala, Honduras) or areas suffering military conflicts (Afghanistan, Yemen).

Thus, even small changes in income and GDP will be perceived as a larger income shock to individuals living near or below the poverty line. Individuals with very little capacity will ignore pandemic social distancing directives quicker than those with higher capacity, otherwise they will not have money for day-to-day food and basic necessities.

The perceived relative economical loss (c_3) displays sensitivity of the society to the change in the GDP. If a country is affluent (as reflected by its higher GDP) then c_3 must be of a small value. These countries are less sensitive to any drop, or relative drop, in their GDP. Countries with greater capacity are able to erect more stringent and additional Swiss Cheese Model safeguards. Low-income GDP countries are more sensitive to the changes in the economic cost, thus their c_3 value will be larger. This results in a fluctuation in human behaviors in relation to the economical cost which leads to waves of infections. During a pandemic, social isolation invoked by public health results in a decline in the economy and personal incomes but when the disease transmission (or the perception of disease transmission and risk) wanes individuals with lower capacity will relax their social distancing efforts and change behaviors, returning to work. It results in a resurgence in infectious disease case numbers, which in turn, often results in public health oversight increasing social isolation measures. This effect was observed during the "second wave" of COVID-19 as relaxed NPI measures resulted in a resurgence of detected positive cases in the EU, Africa, Asia, North America and South America [43–45].

4.2 Efficacy, media amplification, and fear as policy resistance influencers

Policy resistance is often cast as a conflict between the Nash equilibrium and the *social optimum* coverage [46]. This can be thought of as the tendency for interventions to be defeated by the system's response to the intervention itself. The role of fear and fatigue in compliance with policy can lead to resistance. Fear as a construct can be driven by media coverage.

Previous coronavirus outbreaks Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) displayed an amplification of risk perception due to media coverage of the outbreaks [47, 48]. Studies affirm that individuals obtain their news about health and medicine from both mass and social media sources. Daily newspapers, TV channels are one of the biggest influencers of public perceptions of risk. The media plays an important role informing individuals about health risks, but it can also distort perceptions through social amplification of risk. The Social Amplification of Risk Framework (SARF) describes the process where some hazards and events become the focus of intense social and political concern and activity (amplification). This occurs even though experts and risk assessment can establish that the risk is of a relatively low probability, while other potentially more serious events receive comparatively little public attention (attenuation). Media coverage can magnify and change perceptions of risk. The alteration of risk by social amplification creates secondary effects such as stigmatization (of people, places, objects, technologies, and ideas), economic losses, and changes to regulatory oversight due to mass distortion of public risk perception [49, 50].

The efficacies of social distancing and media coverage causing amplification of risk perceptions during COVID-19 are crucial in developing policy acceptance or resistance. In many countries public health risk communication promoted a collectivist and altruistic approach while in other countries policy resistance arose to NPIs through social media. Evidence suggests that belief in conspiracy theories undermines engagement in pro-health behaviors and support for public health policies [51].

For example, in the USA expert messaging carried out by the US CDC regarding mask wearing to protect vulnerable individuals in society became co-opted by social media's distortion of risk (ineffectiveness of masks, lowered perception of SARS-CoV2 infection risk, and as an infringement of personal choice) [52]. Under our

model social media misinformation regarding the risk factors can alter the effective transmission rate through the proportion $1 - x$ of those individuals disregarding mask wearing and social distancing.

4.3 Pandemic fatigue and policy resistance as an influencer

Pandemic fatigue is recognized by the WHO to be natural and expected and is manifested through the decline in motivation of people to adhere to the recommended protective behaviors [53]. It is believed that fatigue emerges gradually [54] and is affected by a number of emotions, experiences and perceptions as well as the demographic, socio-economical, cultural, structural and legislative environment ([55, 56];). During those periods, people will perceive personal, social and economic consequences of the social isolations [53]. Later, the perceived cost of infection and potential death will become smaller than the felt loss. For instance, college students reported physical exhaustion and decreased motivation among other feelings with more resilience expressed by senior students [57]. An increased adherence to preventive behavior and avoidance of risky behavior is positively associated with age [55]. A continued preventive behavior was found to be related to older ages; however, all ages grew weary of avoiding risky behaviors like meeting non-household members [55]. The needs of work and low socioeconomic status intensified the risky behaviors whereas lower education exacerbated both low adoption of preventive measures and high practice of risky behaviors [55]. Moreover, reports of regional COVID-19 cases and the fear of death increased the likelihood to implement both preventive measures and avoiding risky behaviors [55]. The disease-behavior-economic model presented in this chapter, including many of those aforementioned factors, showed that human behavior through pandemic fatigue can determine the fate of the epidemic as well as the economic growth.

One factor to overcome pandemic fatigue is resilience or the human ability to adapt to the new circumstances and to accept the existence of the disease risk while coping with it. The WHO recommended four strategies for governments to address pandemic fatigue: understanding people, engagement of people, acknowledgment of hardship, and allowing people to live with reduced risk [53].

4.4 Policy reinforcement of social distancing as an influencer

While most countries around the world implemented early, stringent social distancing policy including lockdowns once the virus began spreading domestically, the Japanese strategy for the COVID-19 outbreak used voluntary guidance for social distancing measures and persuasive messaging. Public health authorities implemented voluntary measures with contact tracing and diagnostic testing. Widely adopted voluntary compliance behaviors appears to have achieved results similar to other countries that used more stringent social interventions (e.g., lockdowns). The policy strategy comes as a trade-off with more healthcare demand and more deaths than if early stringent control was implemented [58]. The strategy's success depends on continued public good will and compliant behaviors. Hofstede cultural dimensions (see **Figure 1**) of high uncertainty avoidance, long-term orientation and masculinity in Japan resulted in high compliance with social isolation. Google mobility data confirms that even in the absence of lockdown the population avoided public transit (e.g., subways, busses, trains), retail stores, and workplaces (see **Figure 3**). The Japanese strategy requires ongoing public health risk communication efforts to maintain high levels of voluntary compliance.

Sweden used no lockdown approach with the public health goals of obtaining herd immunity to COVID-19 (where a threshold is reached where enough of the population would possess immunity to the virus), and secondly as a strategy to minimize economic shock impacts [59]. A similar no lockdown approach was also used in Japan.

In contrast to Japan's voluntary approach, on January 23 2020 China implemented an early mandatory, stringent lockdown strategy in Hubei province affecting 16 cities (including Wuhan) restricting movement of about 57 million people [60]. The unprecedented scale of this lockdown was controversial resulting in an exodus of people out of Wuhan just prior to the lockdown which could have spread the virus. The strategy placed a cordon sanitaire around the city of 11 million people which raised ethical concerns [61]. After 76 days on April 8 2020 Wuhan ended its lockdown [62]. While the Wuhan lockdown was considered a draconian and unprecedented strategy, experts estimated that lockdown in the city of Wuhan prevented between 0.5–3 million infections and 18,000–70,000 deaths at the expense of the economy and in terms of restrictions to personal freedoms [63]. Other countries followed and implemented similar Wuhan-style lockdowns including Italy (provinces of Lombardy and Veneto), Spain, Russia, India and the Philippines [64, 65]. In this way China acted as an "influencer" or role model for other countries that adopted the same type of lockdown, this is an example of reinforcement.

4.5 Economy and outcome inelasticity - social intervention failure as an influencer

Economic downfall due to social interventions including lockdown during COVID-19 have occurred especially in Low- and Middle-Income Countries (LMICs). Other countries like India and Kuwait showed that social interventions failed to effectively reduce local transmission occurring within large migrant laborer populations. The inelasticity occurred with migrant workers in another country (e.g., Indian migrant workers in Kuwait) or workers moving from one state to another state in their home country (e.g., India) [25, 66].

The vast majority of the migrant workers who traveled to Kuwait for work had very limited means. Non-Kuwaiti migrant workers make up more than 60% of the total population and are mostly employed in low-skilled sectors and domestic work. Migrant workers in Kuwait live in cramped dormitories with poor housing conditions having unmaintained and shared toilets, and poor or no ventilation. The lack of social distance and sanitation among occupants resulted in increased COVID-19 transmission among migrant workers [67].

In India, migrant workers usually live and work in megacities under crowded conditions that do not permit social distancing, putting them at an increased risk for disease transmission. Moreover, migrant workers in many LMICs have difficulty gaining access to health care services since they lack health insurance and lack of access to healthcare facilities as a result of administrative barriers [25]. During the COVID-19 pandemic migrant workers from LMICs face conditions that promote inelasticity (communal overcrowded housing, fear of job loss, unsanitary conditions, withheld income and lack of social distancing). Higher GDP countries also encounter this effect but to a much lesser degree with migrant workers (e.g., Canada's Temporary Foreign Worker Program that allows an employer to hire a foreign worker to help harvest crops and fruit) [68]. Many low-income individuals and migrant workers simply cannot adhere to social interventions that reduce transmission risk due to their situation. Their behavioral responses result in unintentional non-compliance and outcome inelasticity.

5. Conclusion

In controlling and managing infectious diseases through social isolation, distancing or vaccination, the role of individual choice is becoming an increasingly important driver that subsequently affects underlying disease burden among the population. In particular, human behavior and social interactions played a significant role affecting the magnitude of the COVID-19 pandemic. Major factors behind such behavioral interactions are losing jobs and forgoing daily income from social distancing, fatigue from social isolation, and/or conscious or unconscious exploitation of uncertainty due to lack of awareness and knowledge. Thus, the dynamics of controlling infection through social isolation is a potentially complex interplay between individual behaviors and disease dynamics, informed by the perceived cost of being socially isolated and infection risks [69]. This complex interplay can be seen as a strategic game and is conveniently modeled and analyzed using the mathematical framework provided by Game Theory [70, 71]. Such behavior-prevalence game theoretical models have already explored vaccine exemption behavior for endemic diseases [72] but there is less emphasis on behavioral interactions like social distancing, especially analysis from the perspective of cultural dimensions of populations and also their socioeconomic conditions. The current study opens up a forum for further research on how individual choice, especially at the population level, is of utmost concern for public health policymakers to curb a pandemic.

Our model scenario highlights the interplay between economic impact and human choice in social distancing measures. Individuals with limited resources must choose between complying with public health guidance (a collectivist approach where personal actions can help the population) at the expense of losing income that is necessary for basic sustenance (an individualist approach). Changes in public policy are essential to combat the long-standing problems associated with health and economic inequities since these are more pronounced during a health care crisis, such as the COVID-19 pandemic.

To address these inequities there needs to be changes in public policy during inter-pandemic phases to ensure planning in place that is activated at the beginning of an outbreak. Policies should act to provide increased resilience and capacity at the beginning of an outbreak to minimize economic losses. Both the public and private sectors can put planning in place to reduce the magnitude of the economic disruption from NPI compliance in the workforce, supply chains, and healthcare system to prevent unforeseen economic crises.

It was suggested that sharing or pooling of available resources and networking can occur at several different levels including: the individual, household, local community, city, state or province, regional and national scale as a strategy to increase resilience and avoid negative mental health and economic outcomes [73].

Pandemic crises such as COVID-19 have particular characteristics within a complex system requiring a number of different types of resilience be addressed including population health resilience (the population recovering from the disease), healthcare system resilience (the recovery of the healthcare system), economic resilience (recovery from the economic consequences) and psychological resilience (individual recovery from fear, anxiety, depression) [74].

In the context of the COVID-19 pandemic drawing on the different types of resilience can reduce psychosocial effects such as depression, anxiety, stress and non-compliance to public health NPIs during curfew, self-isolation and lockdowns. Indeed, previous studies have shown that resilience decreases the negative effects of stress both at the individual and regional levels [75, 76].

The city, regional and country-level attention and support for designated essential workers is important to ensure that they are adequately equipped and compensated for vital services performed to maintain public health standards [74, 75, 77].

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