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Analysis of the Causal Loop Structure of Business Discontinuity and Crisis in Response to COVID-19 of Healthcare Systems in Korea

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A B S T R A C T

In the context of an infectious disease pandemic, public health care institutions are faced with very complex and uncertain situations in which they are expected to continue to perform infectious disease control missions, involving a myriad of national and regional factors. This paper examines whether the 'core business continuity system' of public health institutions is disrupted or restored by the causal loop structures that interact in the infectious disease situations. The study results show that we need to prevent burnout of health care workers and maintain business continuity. This could be accomplished by extra human resources, adjusted working hours, sufficient rest, strengthened safety measures for health care workers, and emotional support, not by coercive sacrifice spirits. It is the linkage between policy, regional and cross-organizational institutions that could prevent the collapse of health care intuitions.

Key words: Business Continuity, Health care system, Burnout of health care workers,

1. Introduction

The Coronavirus disease 2019(COVID-19) has taught us a great lesson that human life can collapse in a moment due to the invisible virus. Casti(2018) argued that in a modern society where high levels of complexity are overloaded, 11 extreme events(X-events) can occur and collapse everything. The collapse of everything means that the whole society systems, communication, finance, travel, etc. will come to a complete halt. Pandemic viruses are one of the 11 extreme events emphasized by Casti and are closely related to the complexity of modern society, the overcrowding of cities and the development of transportation networks. As Casti(2018) pointed out, the COVID-19 pandemic in early 2020 was caused by the ultra-accelerated spread of the coronavirus, and was amplified by the lack of readiness to monitor and control the sudden pandemic situation.

The COVID-19 pandemic has shocked all countries of the world, incomparable to any disaster that humanity has ever faced, with confirmed cases of infected 520 million people and deaths of more than 6.29 million so far. Recently, the spread of COVID-19 has been thanks to the positive effects of wearing a mask, social distancing, testing and treatment, and vaccination, but it is still impossible to accurately predict when this pandemic period will end. However, what is certain is that 'high consequence pathogens', more powerful than COVID-19, will emerge in the future. It could be, a more damaging pandemic with high transmission and fatality rates, resulting in astronomical social costs and overloading of the public health system. Therefore, how to strengthen the capability to respond to public health crises by such unexpected infectious diseases has surfaced as the most serious ‘problem’ that the public health institutions in all countries must address.

This paper aims suggest a more complete infectious disease response system that could prevent business discontinuity in essential tasks, such as PCR testing, epidemiological investigation, and treatment by the Korean public health institutions. The systems have proved successful in maintaining low mortality even during the COVID-19 pandemic. This paper is conducted as an exploratory study to design and build a business continuity plan (BCP). This paper attempted to identify which factors of

the 'core business performance system' are disrupted or recovered by causal feedback structures interacting in the events of highly complex and volatile infectious diseases for successful establishment and implementation of BCPs in public health institutions in Korea

In the context of an infectious disease pandemic, public health care institutions have faced very complex and uncertain situations in which they are expected to continuously carry out infectious disease control missions, subject to constraints of a myriad of national and regional factors. The primary focus of this paper is to identify which causal structures first operate dominantly to ensure successful infectious disease control in the highly complex and uncertain situations, contributing to the amplifying possibility of disease response business continuity, or vice versa. The second focus is to ensure that members of the organizations learn enough about factors around the practical BCPS and will be able to enhance the capability to build human, material, and financial subsystems for response (recovery) before problems turn into uncontrollable states.

2. The Crisis of Business Discontinuity and the Analysis Method

2.1. The crisis of business discontinuity in public medical institutions

After the global pandemic of COVID-19, most countries around the world are facing the worst crisis in history, with millions of people infected with the virus and suffering from diseases, and we witness there are more death tolls than at times of war. While we are responding to the prevention and recovery of COVID-19, threatening to the lifelines of human beings, businesses, and governments, we all experienced severe socio-economic paralysis, disruption of own businesses and suffered from enormous damages that would be difficult to keep us whole.

As of June 20, 2022, South Korea had 18.28 million people, or 35.4% of her population, were infected by COVID-19, but the death toll of 24,451, the third-lowest case fatality rate (0.13%) among OECD countries, behind New Zealand (0.04%) and Iceland (0.05%) (inews24, 2022.04.01.). The reasons why Korea was able to be successful in the K-quarantine were the cooperation of the people who shared a sense of crisis, and the resilient public medical system. The public health system was able to stand without collapsing thanks to the sacrifice of medical staff in the public sector in responding to COVID-19 without giving up on their quarantine missions. In the process of responding to COVID-19, public health care workers devoted themselves to the intensive tasks, such as PCR tests, epidemiological investigations, patient management, and isolation treatment to protect national health.

Public sector health institutions in Korea are now experiencing difficulties in handling the infectious diseases, because these days many health care workers had little experience in the work to control COVID-19, the stress of the possible life-threatening infection overwhelming, and some workers were burned out or even died because of overwork load. According to the WHO (2021) announcement, from January 2020 to May 2021, approximately 80,000 to 180,000 of total estimate of 135 million health care workers worldwide has been reported as dead (WHO, 2021). As of January 15, 2022, in Korea alone, 8,076 health care workers were infected, with 71 people in critical condition, and 15 dead.

As a result of long-period of quarantine work while directly exposed to the risk of their life and their families from COVID-19 infection, most health care workers suffered from overwork load and stress, with many of them suffering from burnouts. They are either quitting their jobs or leaving the hospital to change career. Particularly, it is noted that 40% of nurses working at COVID-19 hospitals in the metropolitan area, where the number of confirmed cases has surged due to the dense population, wish to change their jobs (Lee, 2021); Sedaily, 2021). This phenomenon is very similar both in Korea and the United States. According to the American Medical Association's survey of 20,665 health care workers in 124 health care facilities on workload, burnout and anxiety and depression related to COVID-19, at least 23.8% of doctors and 40% of nurses 40surveyed plan to leave the hospital within two years because of stress and fatigue (Sinsky et al., 2021).

2.2. Research questions and analysis methods

In the K-quarantine, public health care workers are described like "The Little Hero of Haarlem" in the fairy tale of American writer Mary Mapes Dodge, who saved a village by blocking a punctured embankment with his fingers (Wikipedia, 2022). However, if a new pandemic situation of infectious diseases, stronger than COVID19, happens again in future, who will make the sacrifice of blocking the hole in the embankment with their fingers? Despite the mission and sacrifice of medical workers, it will be difficult to expect another success of the K-quarantine. Unless public health institutions' work continuity plans are not properly designed and prepared, future infectious disease responses are likely to create a fatal crisis in chaotic situations. Instead of waiting for a boy hero who will save the village, the public health institutions in all regions should establish a Business Continuity Plan (BCP) to prevent against the crisis of work continuity disconnection.

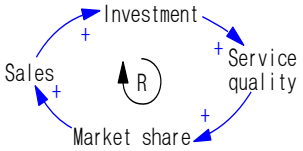
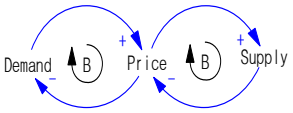
Business discontinuity in public health institutions responding to infectious diseases is affected by many factors, and there is complexity and uncertainty with great volatility depending on the degree of infectious disease outbreak. However, several studies show that the loss of health care workers, due to burnout, or the shortage of health care workers, due to leave or turnover, will create the most severe interruption in the response to infectious diseases (Duarte, 2020[6]; Amartuvshin, 2021; Koontalay, 2021; Sinsky et al., 2021).

The research question of this study is how the business continuity by health care workers affected by the dominant operation of causal loop structures. In the cause loop structures, certain factors interact in the process of responding to COVID-19 in public health institutions, such as public health centers in local governments. This study investigates whether the possibility of business discontinuity is reinforced by current cause loop structure or whether the possibility of business discontinuity is suppressed by the structure

This study intended to overcome the limitations of existing studies that list the work of public health institutions that linearly control COVID-19 like a snapshot from a static viewpoint where human resources are main factors in the structures. In this study, we investigated to see if some causal loop structures help understand the possibility of business discontinuity in the infectious disease response task. The state of discontinuity could be amplified or delayed, and conversely, the possibility of discontinuity or the level of discontinuity could be suppressed. Systems thinking explains the dynamic change state of a system through a positive feedback structure and a negative feedback structure, which are the interaction structures of some endogenous and exogenous variables constituting the system. A positive feedback structure is a reinforcing structure in which two variables affect each other in the same direction, and a negative feedback structure is a balancing structure in which two variables affect each other in opposite directions. In a positive feedback structure, there is an even number of the relationships (+ sign) in the polarity that affects each other between variables, while in a negative feedback structure there is an odd number of the relationships (- sign).

The causal loop analysis of this study is based on systems thinking, as presented in Table 1. The focus of this study is to identify the causes of business discontinuity before establishing a Business Continuity Plan (BCP), the causal loop structure of the problem and discover the feedback loops related thereto. This is an exploratory study conducted before the more in-depth survey of medical personnel in public health institutions. The study went through literature review of existing studies and big data analysis on media news articles, as well as collected factors affecting the disconnection of infectious disease-related tasks. Through the analysis of the contents of articles reported in newspapers and broadcasts, we conclude that it showed public health institutions and health care workers are facing serious problems that may cause system collapse or disruption from the start of the COVID-19 pandemic until recently.

Table 1. Feedback Loop / Structure analysis based on the systems thinking

Feedback Loop	Feedback structure characteristics and examples of simple causal loop diagrams	Diagram sample
Positive Feedback Loop	▷ Exponential increase, self-reinforcing, amplification and deviation enhancement structure ▷ The effect of two variables in the same direction (- relationship is zero or even number) ▷ Example: **R**einforcing Feedback(R)	
Negative Feedback Loop	▷ self-balancing, self-restraining, and stabilization structure ▷ The effect of two variables in the opposite direction (- relationship is odd number) ▷ Example: **B**alancing Feedback(B)	

3. Analysis Results

3.1. Exploring main factors of business discontinuity

In an infectious disease pandemic, such as COVID-19, the essential missions of public health institutions are to control the spread of infectious diseases and treat confirmed patients safely and quickly. Since most of these core tasks are per-

formed by health care workers in public health institutions, the interruption of work continuity occurs when medical personnel are unable to work, due to infection or burnout, while recognizing that their work is very important. The fundamental factors, which affects the discontinuity of the work by health care workers during the infectious disease pandemic, include the risk of infection, the psychological anxiety, stress, and workload. This condition is referred to as burnout. The definition of burnout is the overall physical, mental, and emotional exhaustion which a person feels because of being overworked (Katulka, 2022).

This burnout syndrome is a very important factor that causes the disconnection of infectious disease response tasks not only in Korea but also in almost all countries around the world. According to a report on the impact of COVID-19 on burnout of medical staff, more than 60% of the specialists engaged in the most COVID-19 response tasks in health institutions have experienced burnout (Kang & Park, 2021). 80.8% of Korean nurses experienced burnouts, and as a result, more than 80% of nurses considered changing jobs in the past three months (Todaynews, May 13, 2022). Besides, a recent survey by Nursing Central in the United States (July 2021) found that 95% of nurses felt burned out during the COVID 19 Pandemic, and 91% thought about leaving the nursing profession (Nursing Central, 2021).

In this study, a big data analysis was also conducted on Korean media news articles from the time of COVID 19 outbreak to the latest, or January 1, 2020, to June 1, 2022. Big data analysis used a news search tool provided by the Big Kinds platform. The news search attempted to examine which variables have great relevance by extracting keywords in a diagram method and calculating the Pearson correlation coefficient between keywords on a weekly basis. The linear relationship refers to a proportional relationship in which the graph values of the two keywords increase or decrease simultaneously (KFS, 2022: 50-54).

As shown in Table 2, the analysis result is first between the keyword 'corona 19 patients', which best represents the COVID-19 pandemic, and keyword trends such as 'confirmed case', 'infection spread', and 'infection anxiety'. From the analysis results of very high correlation, it is concluded that Big Kinds big data news keyword trend analysis accurately reflects the actual situation.

As a result of the Big Kinds big data news keyword trend analysis, the correlation between facilities and equipment shortages for responding to infectious diseases increases very closely with more increased patients in the COVID-19 pandemic situation. In addition, when the COVID-19 pandemic situation occurs, "health care workers' infection," "health care workers' anxiety", and "health care workers' fatigue" increase in the same direction, in line with increased health care workers' burnouts. The results of this analysis indicate that there is a strong correlation in which the 'sacrifice of health care workers' increases in the same direction in the COVID-19 pandemic situation. Particularly, it shows that the correlation is very high between the variables related to the disconnection of continuity in response to infectious diseases. In other words, as the number of COVID-19 patients increases, the frequency of keywords for variables, such as "lack of health care workers (0.8575)," "lack of public health center staffs (0.6742)", "business interruption (0.5924), and "medical collapse (0.4601)", increases, an indication of the increased likelihood of business discontinuity.

Figure 1. Keyword Trend Analysis result: COVID-19 patients vs. Health care worker shortage

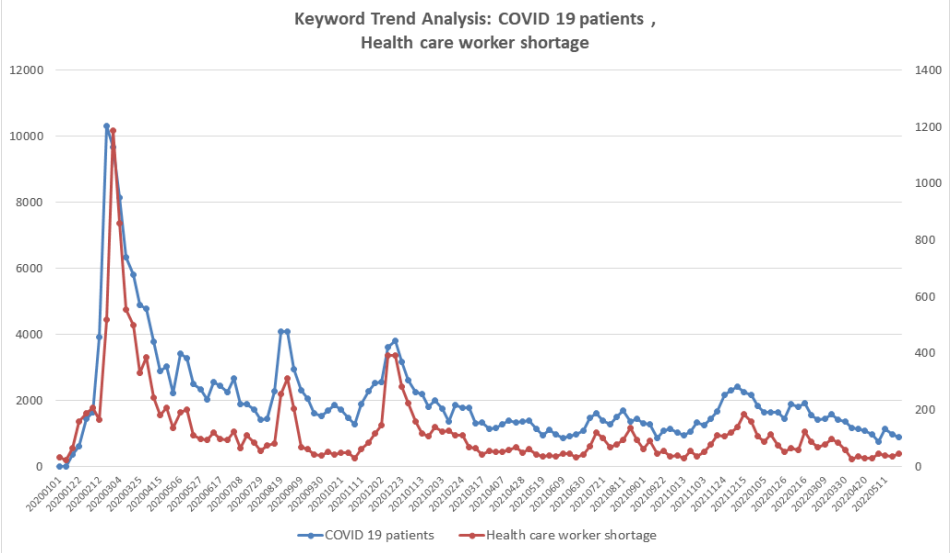


Table 2. Big Data Analysis Results for Key Factors in Business Discontinuity: Correlation[1]

Search Keyword			Pearson Correlation Coefficient	Search result articles (case)
Field	**Search Word 1**	**Search Word 2**		
The spread of COVID-19	COVID-19 test	Confirmed case	0.9209	654,621
	COVID-19 patient	The spread of infection	0.8706	609,473
	COVID-19 patient	Infection anxiety	0.7794	327,992
Physical Factors	COVID-19 patient	Lack of hospital rooms	0.7610	272,699
	COVID-19 patient	Lack of isolation facilities	0.8307	274,700
	COVID-19 patient	Lack of negative pressure isolation room	0.7383	271,737
	COVID-19 patient	Lack of protective equipment	0.5636	271,619
	COVID-19 patient	Lack of medical facilities	0.6740	521,590
Human Factors	COVID-19 patient	Health care workers' infection	0.8960	300,459
	COVID-19 patient	Quarantine for health care workers	0.8546	280,860
	COVID-19 patient	Health care workers' anxiety	0.7835	276,421
	COVID-19 patient	Health care workers' stress	0.4141	272,628
	COVID-19 patient	Health care workers' overwork	0.4760	272,745
	COVID-19 patient	Health care workers' fatigue	0.5775	273,892
	COVID-19 patient	Health care workers' concern of one's family	0.5471	272,604
	COVID-19 patient	Health care workers' burnout	0.1290	272,659
	COVID-19 patient	Health care workers' overtime work	0.5740	271,697
	COVID-19 patient	Health care workers' holiday work	0.3532	271,602
	COVID-19 patient	Health care workers' exhaustion	0.3026	271,861
	Health care worker	Exhaustion and burnout	0.5039	105,782
	COVID-19 patient	Health care workers' safety	0.7979	287,923
	COVID-19 patient	Health care workers' compensation	0.3388	272,946
	COVID-19 patient	Health care workers' sacrifice	0.5059	274,183
	COVID-19 patient	Health care workers' rest	0.3016	272,984
	Period of quarantine for health care workers	Health care workers' risk of infection	0.7943	18,352
Financial Factors	COVID-19 patient	Health center bud Public get shortage	0.3217	271,963
	Public Health center budget shortage	Lack of human resources	0.3249	59,260
Business discontinuity of infectious disease	COVID-19 patient	Lack of health care workers	0.8575	278,638
	COVID-19 patient	Absence of health care workers	0.5137	272,621
	COVID-19 patient	Retirement of health care workers	0.2608	271,695
	COVID-19 patient	Lack of manpower in public health center	0.6742	273,004
	COVID-19 patient	Disruption of the medical system	0.4601	276,250
	COVID-19 patient	Cessation of hospital treatment	0.3543	271,469
	COVID-19 patient	Cessation of work	0.5924	301,387
	Lack of health care workers	Stop of triage test for COVID-19	0.4946	23,007

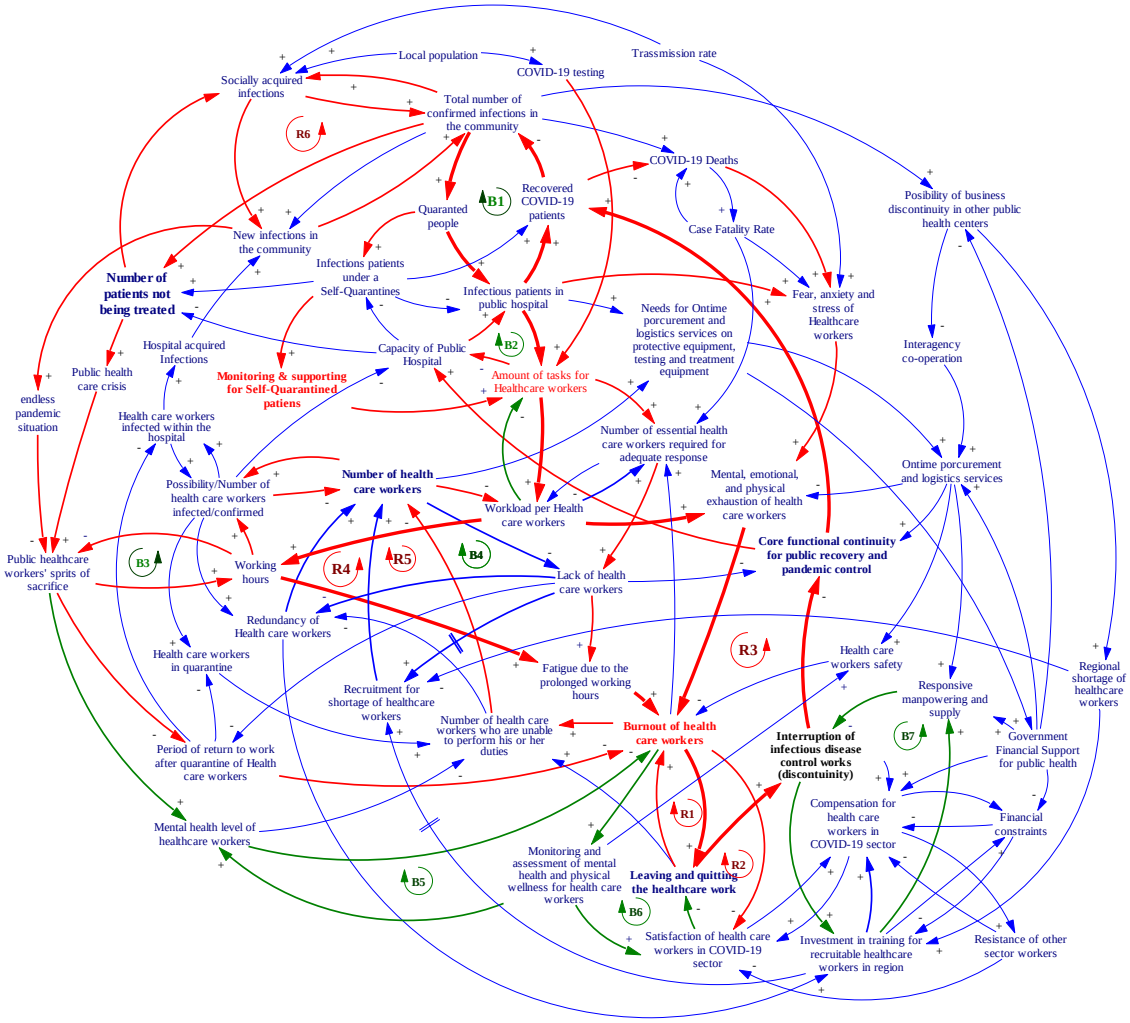
[1] Pearson correlation coefficient in BigKinds keyword trend analysis means that '-0.1 ~ +0.1=almost negligible linear relationship', '+0.1 ~ +0.3=weak quantitative linear relationship', and '+0.3 ~ +0.7= distinct quantitative linear relationship' exist

	Health care workers' infection	Absence of public health center's works	0.2738	62,456
	Health care workers' fatigue	Stop of public health center's works	0.2162	4,769

3.2. Causal loop structure and features that lead to business discontinuity

Figure 2 is an integrated causal map, with system factors and their structures, showing whether the continuity of infectious disease response work in the public medical sector is being disrupted by the COVID-19 pandemic situations.

Figure 2. Causal Loop Structure of Business Discontinuity



In this explorative causal map, there are tens of thousands of feedback loops, where the pandemic situation of infectious diseases, response to it, and disconnection of work continuity are composed of very complex causal feedback structures. This study investigated under what dominant structure the burnout conditions of public health care workers are strengthened and how the conditions may be alleviated.

As can be easily identified through the causal loop in Figure 2, many factors contribute to the burnouts of health care workers. Fatigue is aggravated by health care workers' shortage and increased working hours. Safety of health care workers is declining due to mental health, physical exhaustion, and emotional exhaustion that is difficult to handle with sacrifice spirits. After such a short time for quarantine and rest, the policy of returning confirmed health care workers to the medical field further created burnouts of health care workers. This burnout of health care workers is very serious because it paralyzes the core work of health institutions that try to

control the pandemic situation of infectious diseases and restore the public health. These prevailing burnouts and safety conditions may eventually lead to health care system collapses.

To prevent such a problem, it is necessary to identify and address the factors that cause burnouts of health care workers, including extra workers, adjusted working hours, sufficient rest, strengthened safety measure for health care workers, and emotional support rather than coercive sacrifice spirits. It will be necessary that the linkage should be established among policy, regional and cross-organizational institutions.

The following Table 3 summarizes key points about the business discontinuity in the causal loop, the structural countermeasures and unexpected side effects.

Table 3. Feedback Structure resulting in Business Discontinuity and Framework of Policy Failure

Type	**Feedback Structure about Business Discontinuity**	**Feedback structure about Business Continuity**	**Structure of unintended policy side effects**
Reinforcing Structure **(R1, R2, R3, R4, R5)**	▶ Reinforcing structure in which burnout of health care workers accumulates to discontinuity of core health care system : Reinforcing structures (or factors) that amplify the workload of the health care workers operate ▶ Reinforcing structure in which the morale of healthcare personnel continues to decline : Reinforcing structures (or factors) that amplify the sacrifices and complaints of the health care workers are activated ▶Lack of health care workers → Burnout of health care workers → leaving and quitting the healthcare work → Interruption of infectious disease control works(discontinuity) → Core functional continuity for public recovery and pandemic control	▶Formation, operation, and activation of a balanced structure that relieves fatigue of health care worker ▶Rest, replacement with extra worker, compensation, advanced safety equipment	▶ Forcing excessive compliance with safety product wearing guidelines → Increasing fatigue of health care worker ▶ Attempts to increase manpower reduction by shortening the quarantine period of confirmed health care workers → Amplify the risk of infection of other health care workers and patients → Increased unexpected business discontinuity ▶ Resistance to compensation of health care workers responding to infectious diseases and equivalent demands → Failure to compensate health care workers or increased government financial burden

Balancing Structure **(B5, B6, B7)**	▶ A structure in which supplementation of health care worker and equipment is continuously suppressed and delayed ▶ Lack of budget, lack of extra human resources	▶ Activates the reinforcing structure that continuously expands budgets and extra human resources ▶ Expansion of human resources, equipment, and reserve fund (or factors)	▶ The introduction of new untrained extra human resources leads to a limitation in which the work capabilities of existing health care workers are further reduced ▶ Insufficient compensation for health care workers due to opposition from other actors

4. Conclusion

The COVID-19 pandemic, which came as a black elephant, has halted, or significantly shrank all social and economic activities around the world, with the life-threatening risks posed by the infectious disease. As the business disruptions were unpredictable before the COVID-19 with no plans for preventive measures, many public health institutions experienced extreme and chaotic hardships on the verge of collapsing riverbanks, frustrated by an exponential rise in suspected contacts and confirmed cases. With that lesson, the Korean government instructed all public health institutions to design and establish business continuity plans (BCPs). However, most of the established business continuity plans are very simple and naïve, and they are paying attention only to the simple tools to draft business continuity plans. The current BCP guideline (Guideline) only believes that the problem will be resolved if there is a way to reduce the number of infectious disease response work and draft a list of the countermeasures.

However, the findings of this study showed that there are feedback loop structures in which numerous factors interact in the hidden infectious disease response system, and that business continuity can be interrupted by the dominant operation of these feedback structures, and sometimes counter-recovery structures. In addition, this study revealed that plans, such as shortening the quarantine period of infected health care workers and quickly reassigning them into infectious disease response work, may have negative effects and lead to vicious causal feedback structure, which further reinforces the discontinuity of business.

Successful responses to future infectious diseases require public understanding that incomplete BCPs may increase risks, and public health fundamentals should be strengthened, as emphasized by the National Center for Emerging and Zoonotic Infectious Diseases (NCEZID). NCEZID emphasizes that continuous maintenance of manpower, resources, and technology is essential in building the public health base with strengthened monitoring and control capabilities to attract, keep, and develop a highly skilled and motivated health care workforce.

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