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■ Article

Policy engineering analysis on the initial infection status of COVID-19 and Japan's countermeasures

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Abstract: The transmission of COVID-19 needs to be studied using a multidisciplinary approach, including pathology and statistics, as basic evidence for a pandemic prevention and control response. Statistical and policy analysis of the characteristics of infection and the effectiveness of the response is being carried out using engineering methods. Until now, most studies have focused on the timing and scale of infection from an infectious disease medicine perspective as the basis for response. However, infection patterns are closely related to complex human behaviour, and it is often difficult to find more coherent patterns of infection by focusing on specific regions. In this study, based on open data and through cross-regional comparisons of large samples, we observed common features in the transmission of COVID-19 from a statistical point of view. From the incubation period, it was found that the virus could be divided into a "physical incubation period" (up to two weeks) and a "social incubation period" (up to four weeks). We then analysed the initial policy-engineering measures to prevent the transmission of novel coronaviruses in Japan, and proposed measures to prevent the rebound of novel coronaviruses and other infectious agents, and provided suggestions for future measures.

Keywords: Initial stage of COVID-19 infection, Japan, Policy Engineering, Cruise ship type, Urban type, Physical incubation period, Social incubation period

I. Introduction

Since the outbreak of the coronavirus disease 2019 globally, many nations are facing huge difficulties in looking for optimal solutions to the prevention of further spread of COVID-19. By the end of 2020, more than a whole year past since the first COVID-19 case been confirmed, the total confirmed cases in the world have exceeded 80 million while the total number of confirmed deaths is reaching 2 million people in more than 200 countries, regions, or territories with cases (World Health Organization, 2020). As a result, in this entire year, the COVID-19 influenced not only the medical conditions but also the entire economic systems in the changed world.

Restrictions on human's movement to prevent the spread of virus totally changed human's behavior and have had huge impacts on social and economic activities. The COVID-19 recession is estimated as the most rapid and sharpest degradation among all global recessions from the 1990s and the damage will last for a long time (The World Bank, 2020). Therefore, many economies are not only trying their best but also struggling with how to balance the spread of virus and social economic activities at the same time. To prevent

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COVID-19 and to maintain the economic order, research using an interdisciplinary approach that includes not only medicine but also statistics and policy science is necessary.

This paper chooses Japan as the focus for analyses and discussion. During the past year, comments on Japan’s responses to the epidemic of COVID-19 have been mixed, especially in the early stages. This paper presents a statistical analysis of the characteristics of the initial infection of COVID-19 in Japan in 2020, showing a clearer picture of Japanese domestic anti-epidemic environments and how it is balancing the epidemic prevention and economic revitalization at the same time and to propose recommendations for policy makers.

II. Statistical Analysis of Initial Infections of COVID-19

II. 1 Characteristics of Initial infections in the World

On December 30, 2019, 27 cases of COVID-19 were announced in Wuhan, China, locked down on January 23. In February 2020, after an infected person was discovered on the Japanese "Diamond Princess" cruise ship, a series of countries announced their infection status. In the end, COVID-19 became a global pandemic infectious disease that threatened the global society.

Determining the source of the outbreak of COVID-19 is a scientific problem. However, analysis of infection data from more than 100 countries and regions around the world published by the World Health Organization (WHO), countries, and regions, etc., shows that the early stages of infection can be classified into two major infection types. Figure 1 shows the daily cumulative number of infections in countries around the world after the first infections were announced, including Wuhan and the "Diamond Princess" cruise ship. Type A is named as the "cruise ship type," characterized by rapid outbreaks in high-density areas such as the "Diamond Princess" cruise ship and New York, in which high-density refers to so-called "three-dense" (closed spaces, crowded places, and close-contact settings) environments. Type B, named as "urban type", is more common in urban settings such as Wuhan, China, Japan, the U.S., and South Korea, and is found in most of the world. Figure 2 shows the infection curve and the incubation time to a large-scale infection explosion in specific areas such as Wuhan, New York, Korea, Tokyo, Hokkaido, and Japan.

WHO reports the incubation period of COVID-19 in the human body (i.e., "physical incubation period") is approximately 1 to 14 days, and the average time from infection to onset of symptoms is about a week. In Figure 1 and 2, the incubation period between the announcement of the first case of infection and the outbreak of a large-scale infection (i.e., "social incubation period") is about 7 days for Type A, which is about half of the 14-day physical incubation period. It suggests in a "three-dense" environment such as a cruise ship, it is likely to be conducive to the acceleration and spread of infection. On the other hand, the social incubation period of Type B is about 30 days, which is about twice as the physical incubation period.

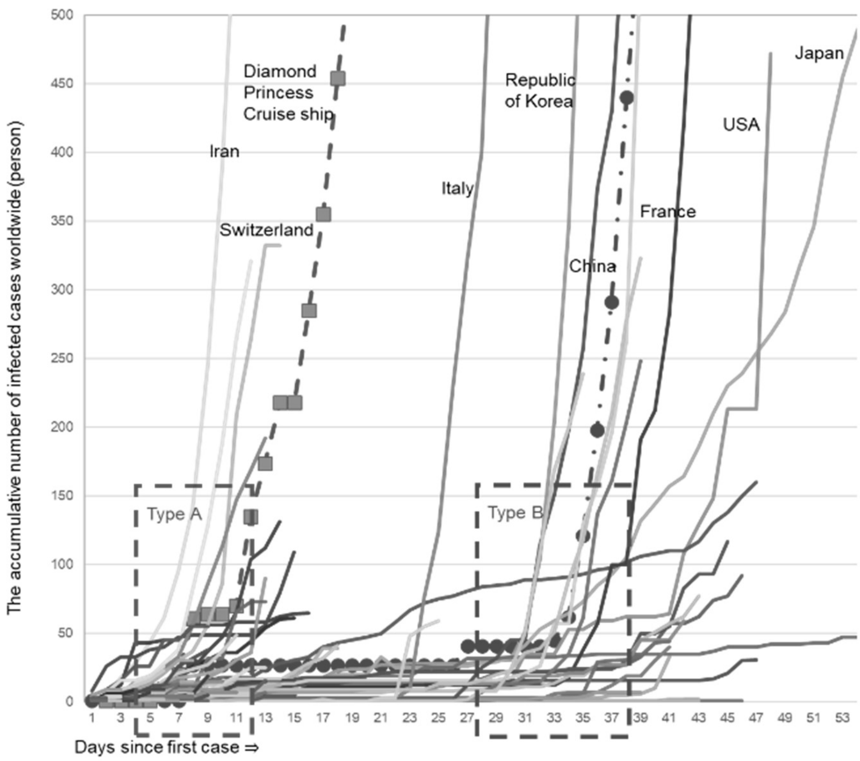


Figure 1: Classification of initial COVID-19 infection characteristics and incubation period until explosion in countries around the world
Source: WHO (2021)

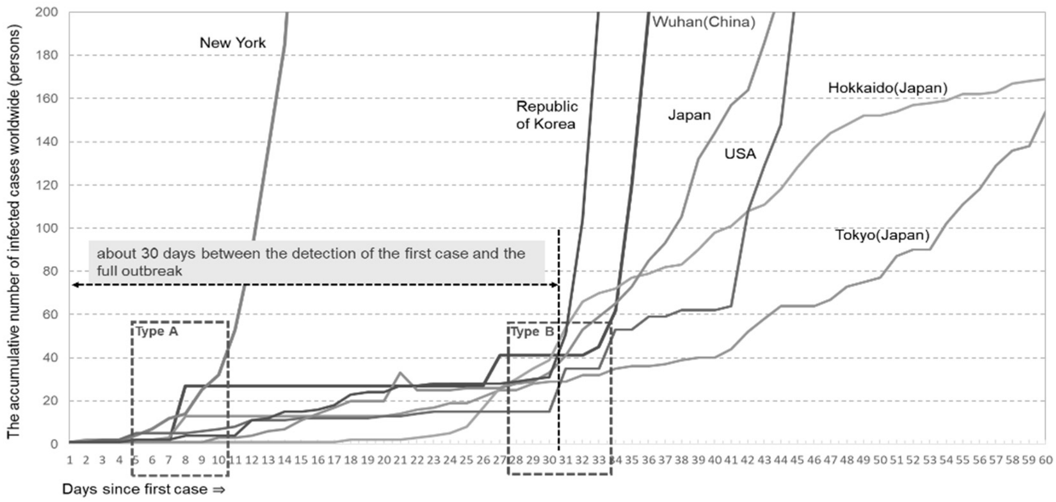


Figure 2: Collective latency periods for specific regions
Source: WHO (2021), Tokyo Metropolitan Infectious Disease Surveillance Center (2021), Hokkaido Government (2021), New York Government (2021)

The above statistical results indicate that there is a clear commonality in the data on outbreaks across countries and regions. Based on this finding, it's important to take decisive action to prevent the spread of COVID-19 within one month of the discovery of the first infection. Furthermore, since the longest incubation period between the first infection and a large-scale outbreak is about four weeks, it is recommended that the quarantine period be changed from the commonly implemented two weeks to four weeks. In other words, the "2-week isolation + 2-week observation (2+2)" response is more effective in preventing the spread of infection. The method of quarantine and observation for the latter two weeks can be handled in different ways depending on the situation in each country or region.

In summary, there are two types of initial COVID-19 infection and two incubation periods respectively. One type is “cruise ship type” which takes about a week from the first infected person to a major outbreak especially in highly dense environment, while another type is “urban type” which takes four weeks from the first infected person to a major outbreak. Accordingly, one incubation period (physical incubation period) is estimated around 1-14 days with an average of 5-6 days, while another (social incubation period) is about 30 days, four times longer than the physical incubation period. The two types of infection and incubation periods mentioned above can be used effectively in considering a more effective response to COVID-19. However, the mechanism of transmission through the population, especially the mutant strains of the virus, is still unclear and needs to be analyzed using an interdisciplinary approach that includes medicine, behavioral science, and even sociology.

II. 2 Initial infection characteristics in Japan

II. 2. 1 Infection status of the cruise ship "Diamond Princess"

Diamond Princess departed the port of Yokohama on January 20, 2020 with a total of 3,711 people on board. On February 1, it was confirmed that a male passenger in his 80s who disembarked in Hong Kong on January 25. Since then, 542 people have been infected in the 18 days, and the ratio of infection to all passengers and crew is about 15% (NHK, 2020). The number of infections increased daily with a quadratic polynomial distribution, and the statistical coefficient of determination R-squared was 0.79. The daily number of infections also increases in a quadratic polynomial distribution, with an R-squared of 0.99 and an average increase rate of more than 45%. This infection rate is almost the same as the average cumulative increase rate of 46% from January 22 (571 infections) to January 31 (11,821 infections), 2020 in Hubei Province where the COVID-19 started to spread.

II. 2. 2 Initial infection status in Japan

In Japan, other than the cruise ship Diamond Princess, the first case of infection was announced on January 15, 2020. The cumulative increase in the number of daily infected persons in Japan shows a quadratic polynomial distribution exponential distribution, with an R-squared of 0.89. The daily cumulative number of infections increased from 29 on February 13 to 73 on February 18, with an average acceleration of 20.4%. This is close to the average increase of 17% in the cumulative number of infections from December 31, 2019 (27 infections) to February 17, 2020 (59,989 infections) in Hubei Province, China, which gives a glance at the speed of infection in Japan. From a statistical perspective, there is a potential risk of further rapid expansion of the number of infected people in Japan in the future (Zhou, 2021).

Furthermore, as shown in Figure 3, the initial infection in Japan can be classified into two explosion periods. The first small-scale infection explosion period starts around February 15 (i.e., one month after the first infected person is discovered), and the second large-scale infection explosion period starts around March 25. It is important to quickly take reliable and effective countermeasures before February 15, the period of small-scale infection explosion. Wuhan was locked down on January 23, 2020, about a month after COVID-19 cases were announced, but Japan did not issue its first "State of Emergency" until April 7, 86 days after the first case was discovered.

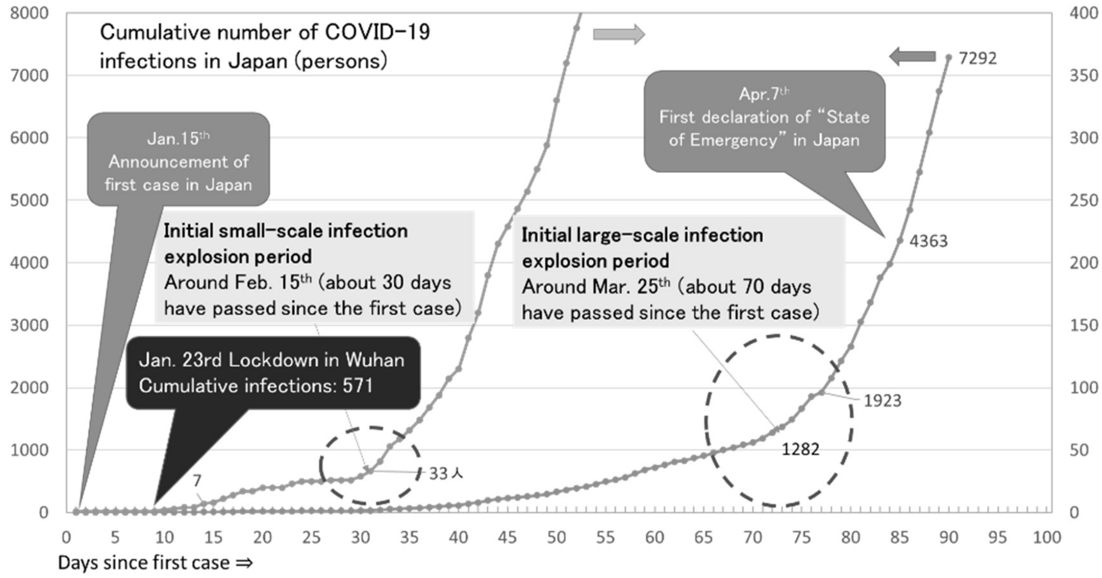


Figure 3: Initial infection curve and two infection explosion periods in Japan
Source: WHO open data

II. 2. 3 Main monitoring items of COVID-19 infection status

Currently, there are six main items being monitored by the Japanese government to capture the general situations of the COVID-19 epidemic (domestic cases) which are a) number of polymerase chain reaction (PCR) tests performed, b) number of persons tested positive, c) number of persons requiring inpatient treatment, d) number of persons requiring inpatient treatment of which the number of seriously ill, e) number of persons discharged or released from care, and f) number of deaths (Ministry of Health, Labour and Welfare, n.d.). This study selected three most important monitoring items (i.e., daily number of new infections; daily number of PCR tests performed; and daily positive rate of PCR tests performed, including their rolling 7-day average values) and did some calculations to analyze the severe situations in Japan against the coronavirus.

a) Daily number of new infections: As the trend of Japanese domestic daily infection of COVID-19 (bars and dashed line) shown in Figure 4, three waves of the COVID-19 daily infections can be observed in the initial stage in 2020. The daily number of new infections in each wave turned out to be much higher and larger than the previous one. At the same time, the time of each wave turned out to be longer than ever before.

The first wave of COVID-19 started around March and ended at the end of May. The peak value reached 590 new infections per day on 18 April, two days after the declaration of "State of Emergency" national wide on 16 April (Ministry of Health, Labour and Welfare, 2020–2021). The valley value dropped to 20 new infections per day domestically on 25 May, and a week later the "State of Emergency" finished on 31 May which was supposed to be relieved 25 days earlier on 6 May as originally planned (`Kinkyu jitai sengen' zenkoku kakudai `tokutei keikai' 13 todofuken shingata korona ["State of Emergency" nationwide expansion "Specific Alert" in 13 prefectures for new coronavirus], 2020).

The second wave of COVID-19 started in the middle June, within half a month after the end of the declaration of "State of Emergency", until October. During this wave, the peak value reached 1595 new infections per day domestically on 7 August which was almost three times higher than the peak value of the first wave. Meanwhile, the valley value of the second wave was 216 new infections per day which was almost 100 times as the one in the first wave (Ministry of Health, Labour and Welfare, 2020–2021). Although the number of daily infections grew much faster than the first wave, there was no declaration of "State of Emergency".

When the second wave of COVID-19 seemed not to subside, the third wave as well as a rather severer one started from the early October right after. During the third wave, the daily number of new infections is increasing steadily and more rapidly. The current peak value of the third wave is 4520 new infections per day on 31 December, breaking the record of daily new confirmed cases, which is 8 times higher than the first peak and 3 times higher than the second one (Ministry of Health, Labour and Welfare, 2020–2021). However, the trend seems not to stop but continue keeping rising by a higher speed in the coming days.

b) Daily number of PCR tests performed: The number of daily new infections of COVID-19 is based on the daily number of PCR tests performed because the number of new confirmed cases are the one of persons who tested positive in PRC inspection. The dotted line in Figure 4 indicates the trend of daily number of PCR tests performed (rolling 7-day average). Compared to the curve of daily new confirmed cases (rolling 7-day average), two trends (the dotted and dashed lines in Figure 4) are surprisingly similar each other. The curve of PCR tests performed also presents three waves like the one of daily new confirmed cases (rolling 7-day average).

To examine the relationship between the daily number of new infections and the daily number of PCR tests performed, the correlation coefficient of two sets of data was calculated. The correlation coefficient between these two monitoring items and rolling 7-day average of the two items are 0.78 and 0.95 respectively, determining that the two sets of data have relatively high positive correlation. Thus, one hypothesis can be developed that the daily number of PRC tests performed can determine the daily number of new infections to a large extent. In addition, the three waves of daily new infections are the fluctuation of daily PCR tests performed. Based on the data and statistical analyses, if the daily number of PCR tests performed keeps rising, the daily number of new infections will also go up, and vice versa.

One reason to explain the high correlation between the daily number of new infections and the daily number of PCR tests performed is the lack of PCR tests and inspections. In the early stage (the first wave), due to the low capacity of PCR tests and high expenses of inspection, the number of PCR tested performed kept low compare to other countries like Korea which firstly implemented different types of large-scale PCR tests across the country. From the second wave, the number of PCR tests have been increasing along with the open for private inspection agency but is still not enough. By the end of 2020, 72,258 is the largest number for daily PCR tests performed which is still far from the maximum capacity of inspection (112,953 PCR tests/day) published by the government (Ministry of Health, Labour and Welfare, 2020-2021).

c) Daily positive rate of PCR tests performed: Daily positive rate of PCR tests performed is the ratio of daily number of new infections, namely daily new positive cases (rolling 7-day average) to daily number of PCR tests performed (rolling 7-day average). The solid line in Figure 4 demonstrates the trend of daily positive rate of PCR tests performed. The curve of daily positive rate of PCR tests performed shows a totally different shape with the ones of daily new confirmed cases and daily number of PCR tests performed.

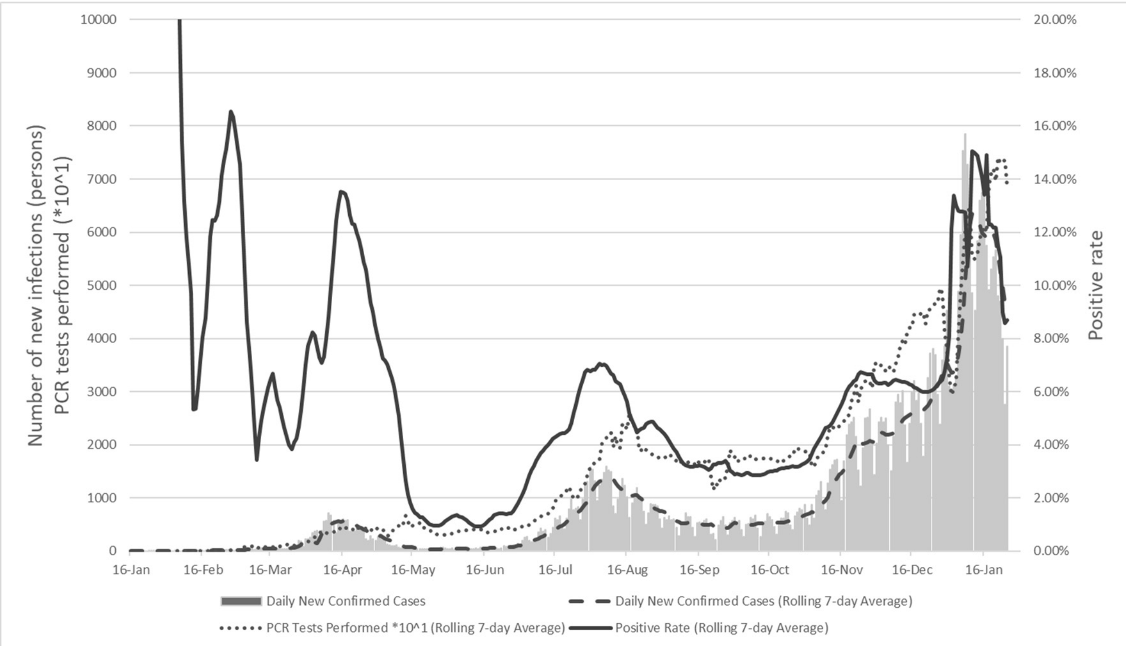


Figure 4: The trend of daily number of new infections, PCR tests performed and positve rate of PCR tests performed in Japan in 2020
Source: Ministry of Health, Labour and Welfare

In the early stage until the dismiss of declaration of "State of Emergency", the positive rate experienced great fluctuation because of the limited PCR tests and inspection systems. During that time, only people who were recognized as the close contacts of infected population and received and contacted by the local public health centers. After that, it reached the peak during July and August and keeps steady in the range from 3% to 8%. But from middle December there was a rising tendency.

III. A policy engineering study on Japan's countermeasures against COVID-19

III. 1 Policy life cycle

Today's social problems are extremely diverse in their scope, causes, effects, dangers, and social and economic impacts. Individual and systemic solutions must be found for each problem. However, most policy issues are determined by key policy decision parameters, i.e., the weight given to individual issues at a given point in time and can be traced through a policy life cycle (Figure 5) consisting of four stages.

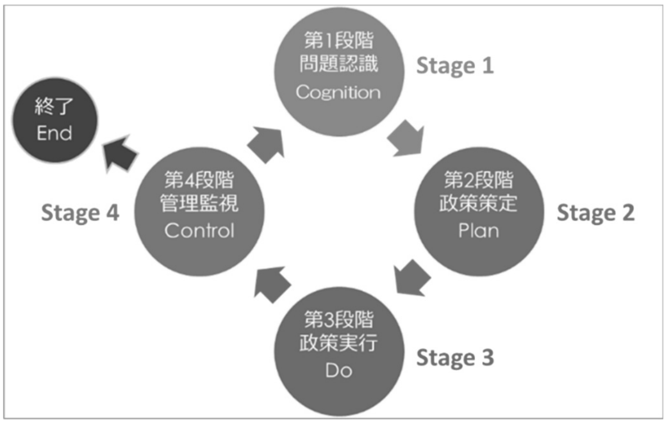


Figure 5: Policy life cycle

Stage 1 is to recognize the problem. In the case of COVID-19, the priority is to elucidate the infection mechanism of the coronavirus. In the beginning of infection, there was generally a significant disagreement between opinions and judgments due to inadequate information on the nature and scale of the problem, current state, future consequences, and its causes and consequences, or so-called uncertainty. Therefore, the key to correctly perceiving a problem lies in how to handle uncertainty. In general, decision theory can be divided into three categories: decision making under certainty, decision making under risk, and decision making under uncertainty. Problem recognition as the first stage is a search for knowledge, which the problem is clarified while dealing with uncertainty.

Stage 2 is the formulation of policies. In this stage, as shown in Figure 6, goals are set to solve the problem through clarification of the causal relationship of the problem, etc., make long-term predictions using mathematical or physical models, and formulate multiple alternative plans (countermeasure plans) to solve the problem. In addition, a "preliminary evaluation" will be conducted on these alternatives based on the evaluation criteria of efficiency, effectiveness, equity and adequacy, and the most appropriate measures will be selected. The main methods used for ex-ante evaluation are efficiency-based methods such as cost-benefit analysis and cost-effectiveness analysis, and effectiveness-based methods such as statistical analysis, quasi experiment, and performance measurement. In the second stage, the political debate on the optimal measures and reasonable cost allocation often intensifies. In this case, not only top-down discussions, but also bottom-up ones (e.g., in the prevention of COVID-19, the opinions and demands of food and beverage businesses and citizens need to be fed back). The key to success is for policymakers to focus on effectiveness rather than efficiency, to find effective solutions without regard to cost, and to manage the crisis after it has passed the congress.

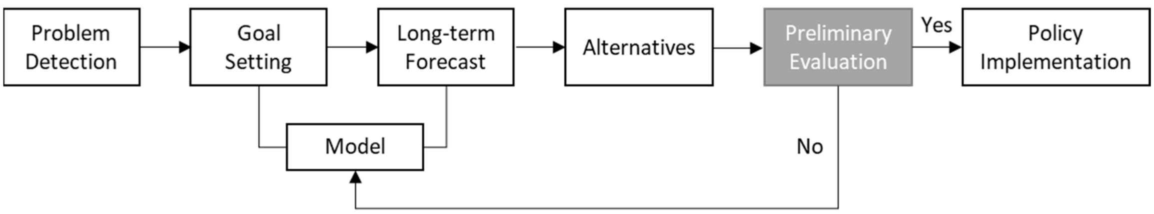


Figure 6: Flow from problem recognition (Stage 1) to policy implementation (Stage 2)

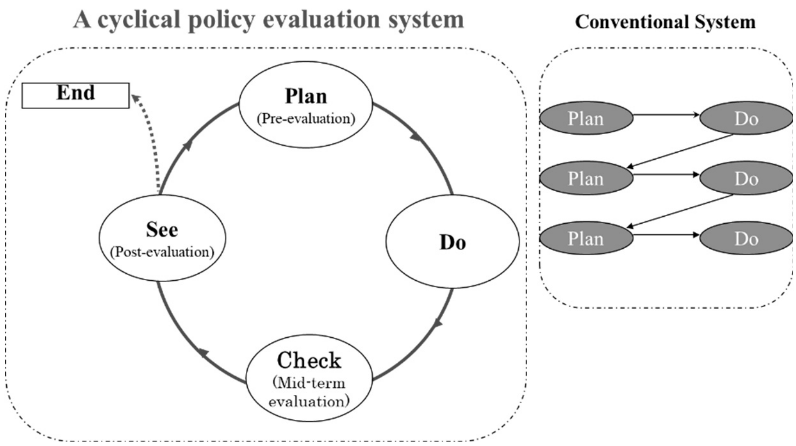


Figure 7: Strategic management system for public policy and administrative planning

Stage 3 is the implementation of policies. After the policy is formulated, it needs to be subdivided into measures (a collection of administrative activities aimed at realizing specific policies based on the "basic policy") and projects (individual administrative tasks and projects to realize "specific measures and countermeasures," which are the basic units of administrative activities) to realize the policy. The implementation of this policy system consisting of policies, measures, and projects often involves high costs and can have significant microeconomic impacts on target groups such as society, industry, and households. During the implementation, "mid-term evaluations" (Figure 7) are conducted to assess and check the effectiveness of the policies and the direction of policy development, etc. As the policy moves into administrative control, emphasis is placed on the implementation of regulations and especially on making them more efficient (tightening regulations), and policymakers focus on efficiency in handling problems.

Stage 4 is "ex-post evaluation" and management (environmental management). When it is confirmed through "ex-post evaluation" (Figure 7) that the improvement of the problem has been realized as planned, and the problem has been mitigated to a degree that is politically, technically, and socially acceptable considering existing information, the fourth and final stage of the policy lifecycle begins, which becomes important rather than ending completely. This means that policymakers must ensure that the problem remains under control. Simplification and possibly elimination (deregulation) of relevant regulations is possible, but careful monitoring must be continued and continuous improvement through ex-post evaluation must be implemented.

III. 2 Policy engineering

Today's social issues are comprehensive in nature, involving a complex interplay of politics, economics and technology, short term and long term, local and global. The policies to solve them are also multidimensional and complex systems. The fusion of the humanities and sciences requires the integration of different disciplines, not only in terms of the subject matter but also in terms of methodology.

As shown in the schematic diagram on the left of Figure 8, the energy input to the energy conversion system is 100%. However, the work energy produced will not be 100%. This is because there is always energy loss. It is the mission of mechanical and physical engineers to pursue the maximization of work energy and the minimization of energy loss.

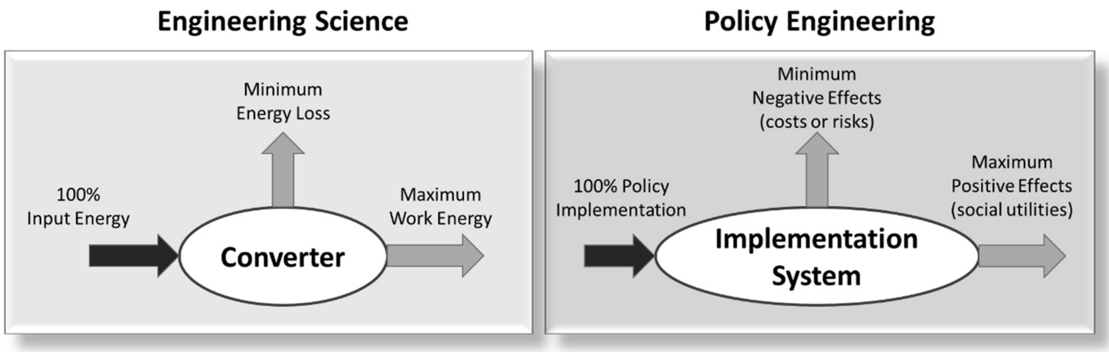


Figure 8: Schematic diagram and similarities between engineering science and policy engineering

On the other hand, as shown in the schematic diagram on the right of Figure 8, if a policy measure is put into the implementation system (real society) as 100%, it will not be possible to obtain 100% improvement effect (social utility, positive effect). There will always be some negative effects. Thus, a scientific methodology is required to maximize the positive effects and minimize the negative effects of introducing policy measures. One of these methodologies is policy engineering.

Policy Engineering is a theory and technique that uses engineering methods to derive optimal solutions to social problems, such as maximizing utility and minimizing cost or risk, and is one of the disciplines that aim to make human cognitive and practical activities scientific. It is a transdisciplinary methodology that transforms a series of processes from problem analysis to policy recommendation (policy life cycle) from conventional "experience and intuition" to one based on "scientific and engineering methods. In other words, it is a discipline that analyzes, formulates, implements, and evaluates the efficiency, effectiveness, and fairness of the policy life cycle from the perspective of time, space, and measures.

While policy priorities vary from country to country and issue to issue, and it is natural that some areas are well advanced and others lag, it is possible to get a general idea of the progress of major policy issues in each country through the policy life cycle. It should be noted that progress varies greatly from region to region. An issue may have reached Stage 4 in some countries, but may still be at Stage 3 in others, or may remain at Stage 2 or Stage 1.

III. 3 Lessons learned from the first wave of infections and the first declaration of “State of Emergency” from a policy engineering perspective

On January 23, 2020, the city of Wuhan, with a population of 12.3 million, was put on lockdown to prevent COVID-19. The first case of infection in Japan was officially announced on January 15, 2020, then a small-scale infection explosion period occurred around February 15 (about 30 days after the first infected person), and a large-scale infection explosion period occurred around March 25 (about 70 days after the first infection). The lockdown measures taken in the large-scale city of Wuhan demonstrated the hazardous nature of the COVID-19 and the difficulty of preventing them and set off alarm bells in Japan and around the world for measures against the COVID-19. Up to this point, it can be said that the first stage of the policy life cycle is "recognition of the problem".

Furthermore, due to the rapid increase in the number of infections in Japan from mid-February 2020, legal preparations to take countermeasures will begin due to the sense of crisis as a domestic problem and the urgency of taking countermeasures. On March 13, the Order for Enforcement of the Act on Special Measures against a New Type of Influenza, etc. (Cabinet Order No. 122 of April 12, 2013) was revised (Act No. 4 of March 13, 2020) so that countermeasures and measures can be taken promptly and accurately according to the situation of the new coronavirus infection. This allows the Prime Minister to make a declaration and designate a period and area for emergency measures in the event of a nationwide and rapid spread of the disease, which could have an enormous impact on people's lives and the economy. The prefectural governor of the target area can request residents to refrain from going out and to cooperate in the prevention of infection, except when necessary for the maintenance of daily life. They can also request or instruct the closure of schools, restrict the use of facilities where many people gather, such as department stores and movie theaters, and use land and buildings for the construction of temporary medical facilities without the consent of the owners if it is particularly necessary. In addition, in case of emergency, the government can request or instruct transportation companies to deliver medicines or medical equipment or expropriate medicines if necessary. This brings to Stage 2 of "policy formulation".

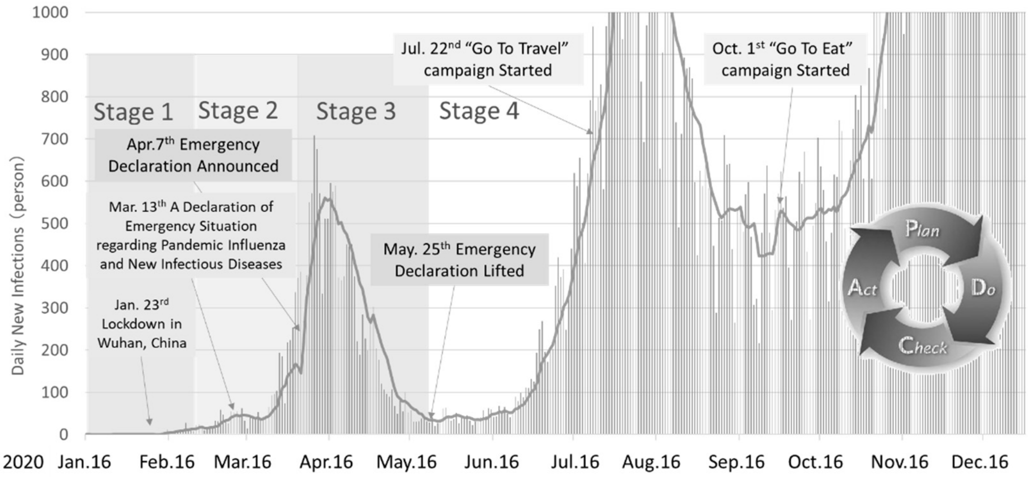
On April 7 with 317 infections, the first declaration of “State of Emergency” was issued as a measure based on the Act on Special Measures against COVID-19, which was passed on March 13, and Stage 3 of policy implementation began. The number of daily new infections peaked at 560 on April 14, and since then, the number has declined rapidly, and by May 25, the deadline for the first declaration of “State of Emergency”, the number of daily new infections nationwide had dropped to 33. On May 25, the "State of Emergency" was lifted nationwide, and then Prime Minister Abe proudly stated, "We have demonstrated the power of the ‘Japanese model’". The "Japanese model" in this context was generally evaluated to be the fact that the number of infections and deaths per capita was an order of magnitude lower than in Europe and the U.S., preventing overshoot (explosive spread of infection) and avoiding medical collapse. However, as shown in Table 1, a comparison of the indicators of the number of infected persons per million population and the number of deaths per million population shows that Japan's performance is not so good that it can be called a "Japanese model”.

Table 1: International comparison of COVID-19 infection status (as Mar. 28th, 2021)

	Population (million)	Cumulative Infections	Number of Infected Persons per Million Population	Cumulative Deaths	Number of Deaths per 100 Infected Persons
Fujian	37.93	560	15	1	0.2
Guangdong	115.21	2267	20	8	0.4
Zhejiang	58.50	1323	23	1	0.1
Hainan	9.45	171	18	6	3.5
Hong Kong	7.43	11445	1540	205	1.8
Taiwan	23.60	1020	43	10	1.0
China (Mainland)	1400.05	102680	73	4851	4.7
Japan	124.78	467112	3744	9035	1.9
Korea	51.63	101757	1971	1722	1.7
Vietnam	97.34	2586	27	35	1.4
Thailand	68.02	28657	421	93	0.3
Singapore	5.70	60288	10578	30	0.05

Source: WHO and CDC of China (population as of 2019)

Less than 20 days after the declaration was lifted on May 25, 2020, the second wave arrived again nationwide (Figure 9). By region, Tokyo entered the second wave immediately after the lifting of the first "State of Emergency", while Osaka, Kyoto and Hyogo prefectures entered the second wave almost a month later (Figure 10 & 11). The key reason for entering the second wave is the nationwide downward trend as of May 25, which is a good sign for convergence of the outbreaks and certainly allows for deregulation and other measures to be taken, but it is not a sign that the "State of Emergency" can be lifted completely, and Stage 4 - the control and monitoring phase of the policy lifecycle. In other words, policymakers must continue to ensure that infection prevention is placed under controlled surveillance.



Source：Ministry of Health, Labour and Welfare of Japan, compiled by the authors

①Stage 1＝Problem cognition (The key to success lies in handling uncertainty.)
②Stage 2＝Policy formulation (preliminary evaluation) (Optimal measures and reasonable cost allocation, focus on effectiveness rather than efficiency)
③Stage 3＝Implemenataion (mid-term evaluation) (High cost, focus on efficiency (more regulation). Decentralization of responsibility and authority.)
④Stage 4＝ Management (post-evaluation) (Need to continue to ensure problem management and careful monitoring.)

Figure 9: Policy life cycle and lessons learned from the first declaration of "State of Emergency"

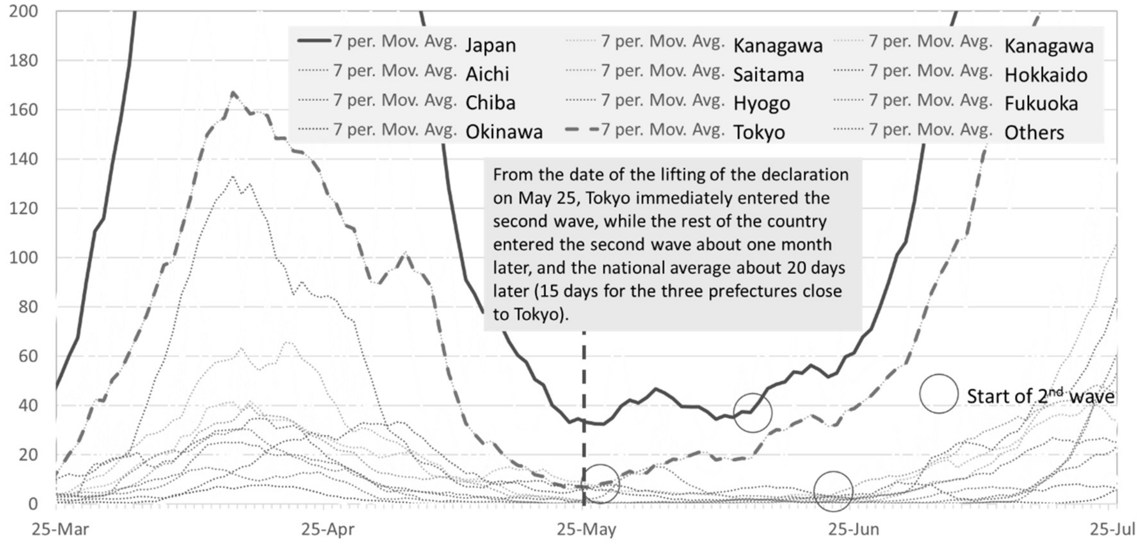


Figure 10: Infection status in the top 10 regions in Japan after the first "State of Emergency" was lifted

Source: Ministry of Health, Labour and Welfare of Japan and NHK

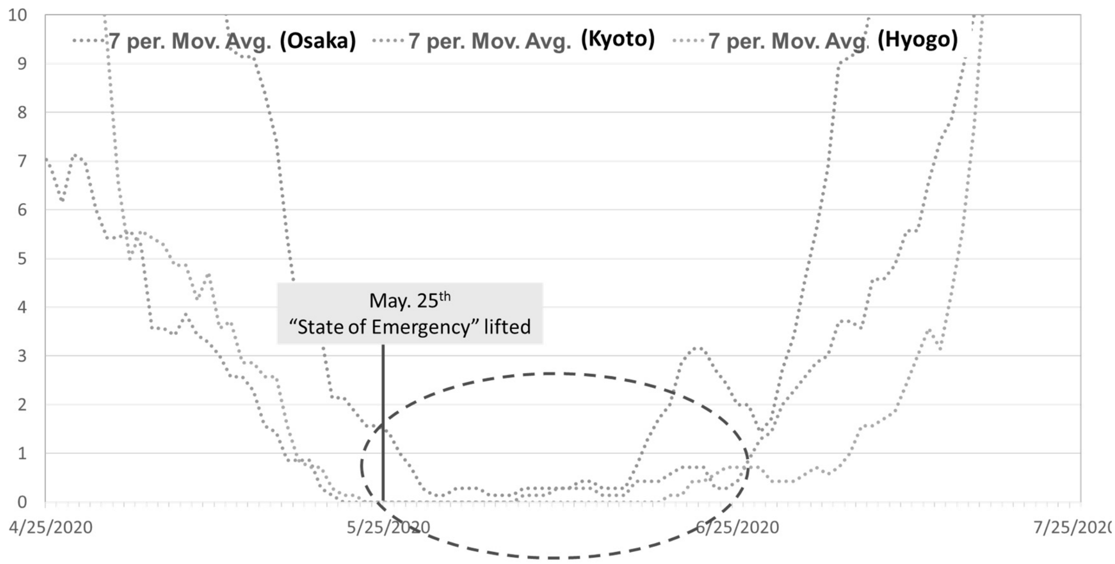


Figure 11: Infection status after Osaka and Kyoto prefectures and Hyogo Prefectures lifted the first "State of Emergency"

Source: Ministry of Health, Labour and Welfare of Japan and NHK

IV. Conclusions

COVID-19 has inevitably had a significant impact on globalization. This research has mainly used statistical and policy engineering methods to analyze the initial stage of the infection of COVID-19 in Japan. From a statistical point of view, the quarantine period is suggested to be reconsidered extending from 2 weeks to 4 weeks (2 weeks isolation + 2 weeks observation), because the incubation period from the first case of infection to the explosion of large-scale infection is approximately 4 weeks, according to the statistical results of the initial infection situation worldwide conducted in Section 2. From a policy engineering perspective, policies of the prevention of the spread of COVID-19 should be revised especially about the declaration and lift of the "State of Emergency" and countermeasures to prevent the rebound of next wave of explosion of COVID-19.

Additionally, the following suggestions are made for countries to cooperate to prevent the expansion of COVID-19 in the future: 1) Domestic prevention and control of COVID-19 cannot be relaxed yet, and the form should be changed. It is necessary to balance the control of virus and economic activities and to coexist with viruses. It is essential to transform and explore endogenous development from the establishment of a country through trade. Foreign markets are supposed to go hand in hand with domestic markets, and actively develop and cultivate domestic markets. 2) Countries must cooperate to achieve domestic goals first, because there are still many uncertain factors in the future including non-traditional security issues, such as climate security, food security, and public health security, together with the COVID-19 pandemic. 3) Under the COVID-19 pandemic, changes of the mode of production and economic development are necessary. Cyberspace is supposed to be highly integrated with real space to promote the digital economy with the sustainable society characterized by low carbon, recycling, symbiosis, security, and intelligence to achieve the Sustainable Development Goals.

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新型コロナウイルス初期感染状況と日本の対策に関する政策工学的分析

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【要旨】新型コロナウイルス感染症の伝播は、パンデミックの予防・制御対応の基礎的証拠として、病理学と統計学を含む学際的アプローチで研究する必要がある。2020 年 2 月より、世界保健機関を含む国際機関が公表している感染症データをもとに、102 の国・地域を対象に、統計学・政策工学的手法により、感染特性や対応効果に関する統計解析を行っている。これまでは、対応の根拠として、感染症医学的な観点から、感染の時期や規模に着目した研究がほとんどであった。しかし、感染パターンは複雑な人間行動と密接に関係しており、特定の地域に着目しても、よりまとまった感染パターンを見出すことは困難な場合が多い。本研究では、オープンデータに基づき、大規模サンプルの地域横断的な比較を通じて、統計的な観点から新型コロナウイルスの伝播に共通する特徴を観察し、集団感染のスピードからは「クローズ船型」（約 1 週間程度）と「都市型」（約 4 週間程度）に、感染潜伏期間からは「身体型潜伏期」（最長 2 週間）と「社会型潜伏期」（最長 4 週間）に分けられることが発見された。そのうえで、日本における新型コロナウイルス感染防止のための政策工学的な初期対策を分析し、新型コロナウイルス等のリバウンドを防ぐための対策を提案し、今後への対策に示唆を与えた。

キーワード：新型コロナウイルス感染初期対策,日本新型コロナウイルス,政策工学,クローズ船型,都市型,身体型潜伏期,社会型潜伏期