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INFLENCE OF DAMAGE TO LIFELINE ON PERFORMANCE OF HOSPITALS IN THE 2018 HOKKAIDO IBURI-TOBU EARTHQUAKE IN JAPAN

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Abstract

This paper focuses on performance of hospital in the 2018 Hokkaido Iburi-tobu Earthquake in Japan. Hospitals are important bases in an earthquake. Since hospitals are also affected by the earthquake, it is necessary to grasp the situation of damage to hospitals just after the earthquake in order to maintain the medical function after the earthquake. We conducted a questionnaire survey on the damage to hospitals in the 2018 Hokkaido Iburi-tobu Earthquake in order to clarify a crucial damage affected to the performance of hospitals after the earthquake. An earthquake of about 35 km in depth and magnitude M_{JMA}=6.7 occurred at east of Iburi region in Hokkaido at 3:07 local time on September 6th, 2018. The human damage of this earthquake were 41 deaths, 18 seriously injured and 731 minor injured. There were 409 completely destroyed, 1,262 partially destroyed and 8,463 slightly damaged houses. 2,249 non-residential buildings were also damaged. The main cause of these damages was landslides occurred at Atsuma town near the epicenter. Water stoppage was occurred at about 68,000 households in 43 waterworks bureaus just after the earthquake. Water supply was recovery in few days in the most waterworks bureaus, however 34 days were required for recovery from the water stoppage at Atsuma town. Furthermore, all power plants in Hokkaido stopped emergency just after the event, and a massive power outage of 2.95 million households occurred. The blackout was completely eliminated was October 4th. Therefore, this study especially focuses on the effects of damage to lifelines on performance of hospitals. The results of analysis of responses of questionnaire survey could be summarized as follows;

1. Structure damage of hospitals by the earthquake did not occurred so much, so the performance of hospital was not affected by the structure damage in this earthquake.

2. An impact rate is defined by the number of hospitals affected to the performance by the damage divided by the number of hospitals suffered by the damage. The impact rate of electricity was 100%, that of water was 50%, and that of gas was 29.4%, respectively.

3. An alternative electricity reduced the effect of power outage on the performance of hospitals. But twelve hours or more of power outage increased negative effects to the performance of the hospital so much.

Keywords: performance of hospital, lifeline, the 2018 Hokkaido Iburi-tobu Earthquake, questionnaire survey

1. Introduction

An earthquake of about 35 km in depth and magnitude M_{JMA}=6.7 occurred at east of Iburi region in Hokkaido at 3:07 local time on September 6th, 2018. A maximum JMA (Japan Meteorological Agency) seismic intensity of 7 was observed at Atsuma town [1]. The human damage of this earthquake were 41 deaths, 18 seriously injured and 731 minor injured. There were 409 completely destroyed, 1,262 partially destroyed and 8,463 slightly damaged houses. 2,249 non-residential buildings were also damaged. The main cause of these damages was landslides occurred at Atsuma town near the epicenter. Uplift and sinking of road and inclination of houses were caused by liquefaction in the southeastern part of Sapporo city. Enormous liquefaction induced damage occurred in a wide area of Satozuka and Utsukushigaoka towns in Kiyota ward, Sapporo city. Water stoppage was occurred at about 68,000 households in 43 waterworks bureaus just after the earthquake. Water supply was recovery in few days in the most waterworks bureaus, however 34 days were required for recovery from the water stoppage at Atsuma town [2]. Furthermore, all power plants in Hokkaido stopped emergency just after the event, and a massive power outage of 2.95 million households occurred. The blackout was completely eliminated was October 4th.

Hospitals are important bases in an earthquake. Since hospitals are also affected by the earthquake, it is necessary to grasp the situation of damage to hospitals just after the earthquake in order to maintain the medical function. We conducted a questionnaire survey on the damage to hospitals in the 2018 Hokkaido Iburi-tobu Earthquake in order to clarify a crucial damage affected to the performance of hospitals after the earthquake.

There are many studies have conducted relating to earthquake damage to medical institutions and medical functions in the past. Kou et al. [3] studied an earthquake damage and deterioration of medical function by using the seismic intensity scale. Inagaki [4] clarified the relation between strength of earthquake ground motion and damage to medical institution but did not focus on medical function. Although Banba and Higashihara [5] and Ikeuchi et al. [6] focused on the influence on medical functions. However, not much research on the degree of deterioration of medical functions by the earthquake damage has be done. The authors conducted a questionnaire survey of functional damage to hospital and lifelines in the 2016 Kumamoto Earthquake in Japan[7]. This study aims to clarify the degree of deterioration of medical function due to the damage to lifeline.

2. Method

2.1 Target hospitals

A questionnaire survey was conducted in the areas suffered building damage and lifeline damage by the 2018 Hokkaido Iburi-tobu earthquake. The hospitals having the bed, registered in the medical association in Hokkaido prefecture were targeted in this study. Hospitals not considered to be important base facilities in conducting life-saving and rescue activities, such as ophthalmology, dentistry etc., were excluded [8].

2.2 Outline of questionnaire survey

The purpose of the study is to grasp the earthquake damage that leads to deterioration of the medical function in the hospitals in the earthquake. For that reason, we investigated six items as follows, hospital specifications, building damage, lifeline function damage, facility damage, medical equipment damage, and medical activity after the earthquake. Table 1 shows details of the each item of the questionnaire.

The questionnaire survey sheets were mailed to 365 hospitals on October 31, 2018, then responses were obtained from 68 hospitals. Therefore the questionnaire collection rate was 18.6%. The location of the hospitals that were responded is shown in Fig. 1. JMA seismic intensity is also shown in this figure. According to this figure, many hospitals are located at Sapporo city and its visinity, and JMA seismic intensity at areas of hospital was 3.5 to 5.5. The number of responses is not enough if damage in each seismic intensity is discussed. So the relation between the seismic intensity and the damge is not discussed here but the degree of damage and the deree of deterioration of medical function is diccussed in this study.

Table 1 – Details of each item in quastionnaire.

Survey item	Details
Building damage	Structual element damage
	Non-Structual element damage
	Furniture and fixtures damage
	Damage to chemicals
Lifeline function damage	Blackout
	Water stoppage
	Gas supply interception
Facilities damage	Plumbing damage
	Air Conditioning / Electricity
	Elevator facilities
Medical equipment damage	Damage to medical equipment such as artificial dialyzer
Medical activity after the earthquake	Outpatient hospitalization and transfer
Hospital specifications	Number of floors, building type

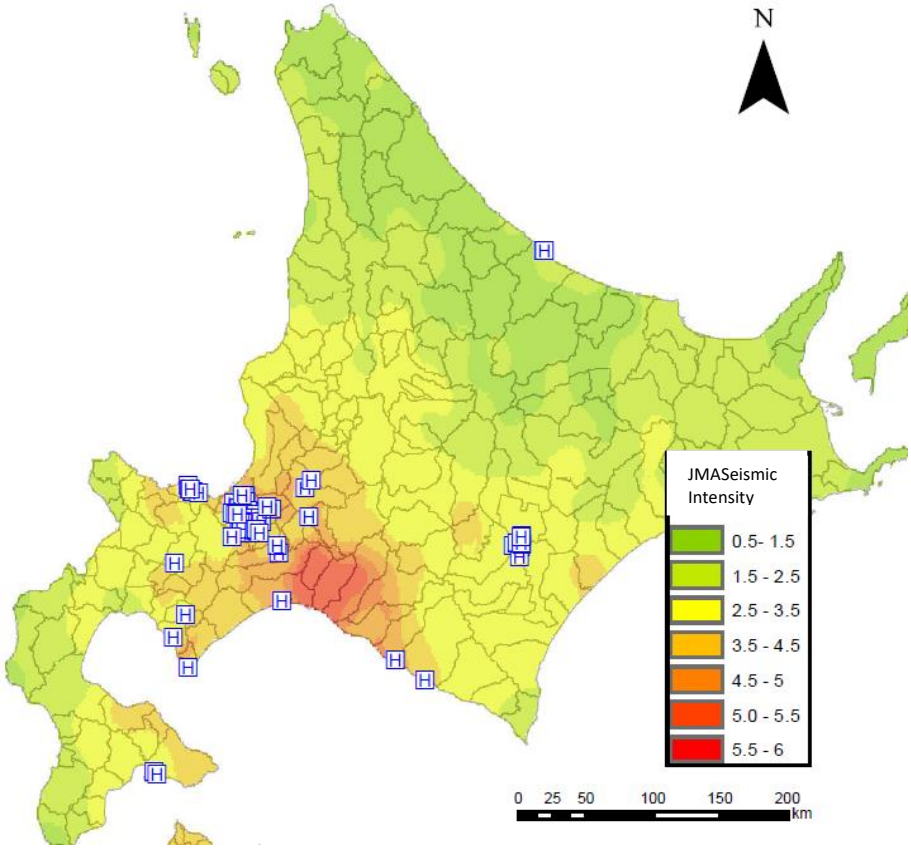

Fig. 1 – Location of hospitals ansered and distribution of JMA seismic intensity.

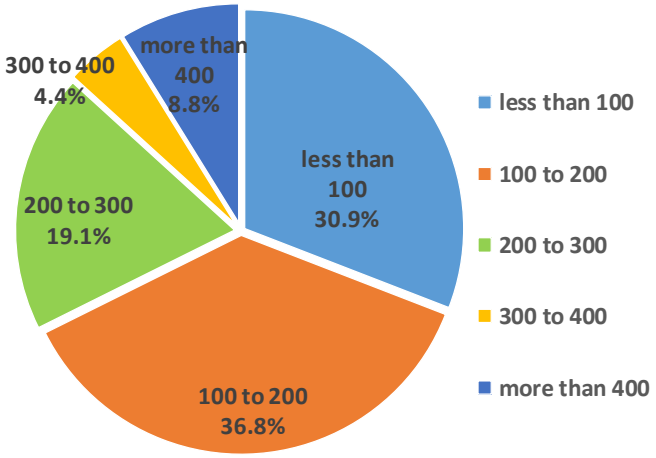

Fig. 2 – Number of bed in each hospitals answered.

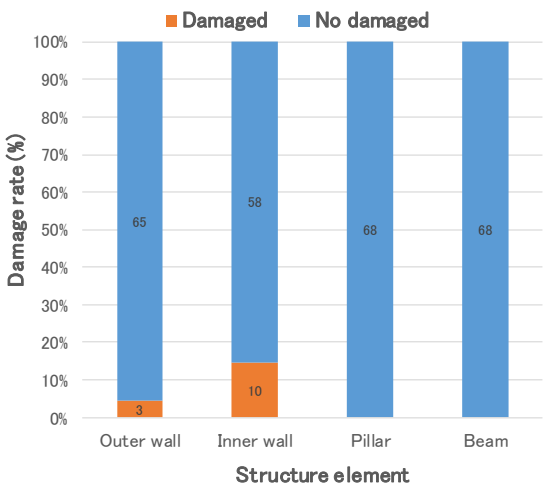

Fig. 3 – Damage rate of structure element

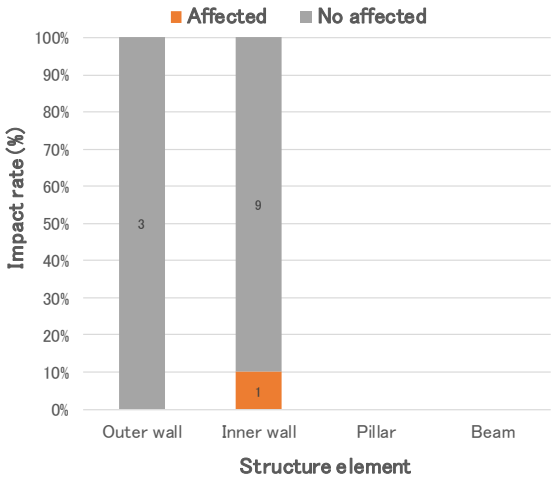

Fig. 4 – Impact rate of structure element

Fig. 2 imdicates percentage of number of bed of each hospital that answered this survey.

3. Summary of damage

3.1 Structure element damage

We focused on the damage to outer wall, inner wall, pillar, and beam as a structure element of building. Type of structure of more than 90% of all answered hospitals is reinforced concrete. So difference of type of structure is not focused in this study. Fig. 3 shows the damage rate and Fig. 4 shows the impact rate of structure element, respectively. In this study, the damage rate is defined as the number of the damaged hospitals divided by the total hospitals. And the impact rate is defined as the number of hospitals affected on medical function divided by that of the damaged hospitals. These figures indicate that the structure element damage occurred at 4.4% of outer wall and 14.7% of inner wall. The impact rate was only about 10% of inner wall.

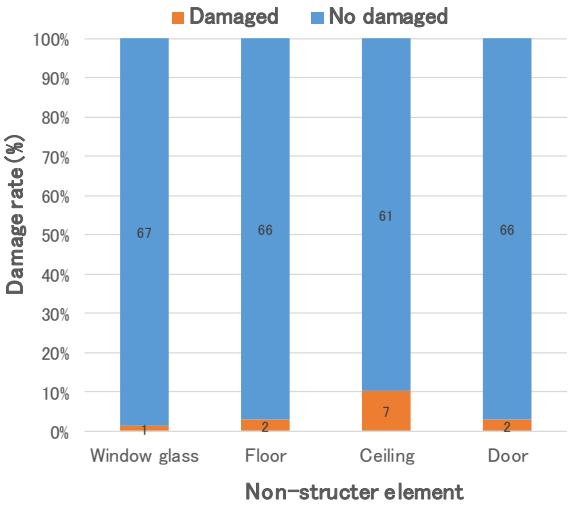

Fig. 5 – Damage rate of non-struature element

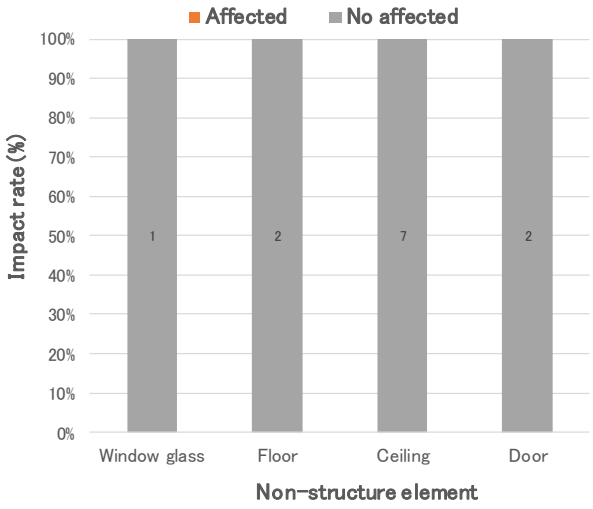

Fig. 6 – Impact rate of non-structure element

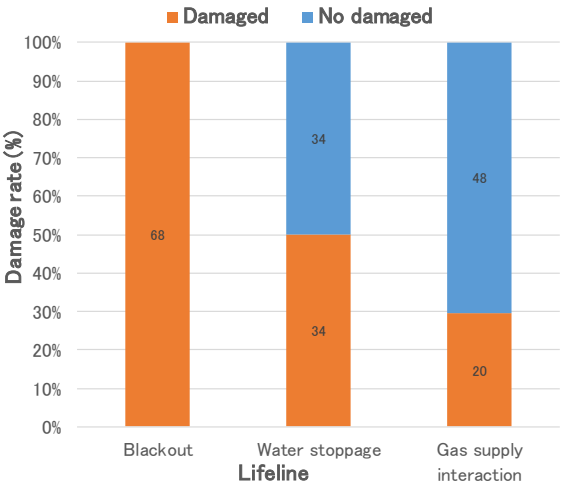

Fig. 7 – Damage rate of lifeline function

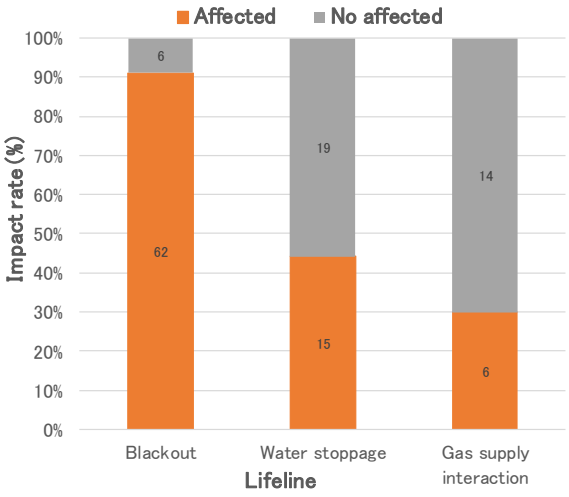

Fig. 8 – Impact rate of lifeline function

3.2 Non-structure element damage

We investigated the damage to window glass, floor, ceiling, and door as a non-structure element. Figs. 5 and 6 show the damage rate and the impact rate of non-structure element, respectively. The damage rate of non-structure element was 1.5% of window glass 2.9% of floor, 10.3% of ceiling and 2.9% of door, respectively. The impact rate was 0% of all element. The impact of damage to structure and non-structure elements on performance of hospital was very small according to the results of the questionnaire.

3.3 Lifeline function damage

We focused on the functional damage to lifeline such as blackout, water stoppage, gas supply interception. Figs. 7 and 8 show the damage rate and the impact rate of lifeline function, respectively. The damage rate of lifeline function was 100% of electricity, 50.0% of water supply and 29.4% of gas. The impact factor was 91.2% of blackout, 44.1% of water stoppage and 30.0% of gas supply interception. The medical functions were influenced mostly by blackout because the damage rate and the impact rate were more than 90%. The

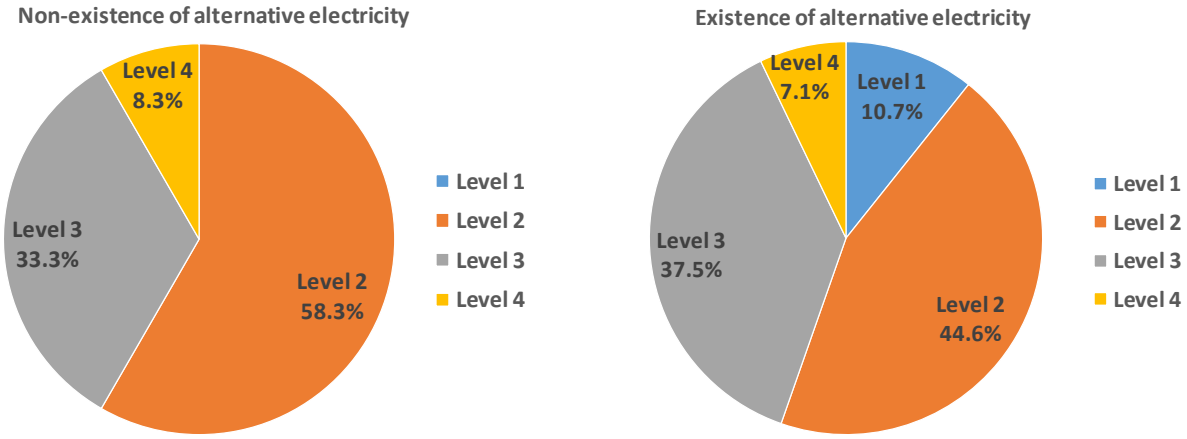

Fig. 9 – Impact revel of blackout on hospitals of non-existence and existence of alternative electricity

impact rate of water stoppage and gas supply interception were also higher than those of structure element and non- structure element. It is clarified that the damage to lifeline function has large influence on the medical function.

4. Impact of blackout on performance of hospital

Impact of blackout on medical function is discussed here because the impact rate of the blacout was largest in our survey. We classified the impact levels of medical function into five levels to analyze the impact of each damage on the medical function as follows; Level 0: No damage, Level 1: No influence of damage on medical function, Level 2: Restriction of service hours of medical treatment, Level 3: Suspension of outpatients Level 4: Transfer of patients due to damage. We discuss the impact of blackout by using the impact level defined here.

Fig. 9 indicate the relation between impact level of blackout in hospitals with existence and non-existence of alternative electricity such as battery or private electric generator. 8.3% of the hospitals of non-existence of alternative electricity is the impact level 4 and no hospitals of the impact level 1. On the other hand, the impact level 4 of hospitals of existence of the alternative electricity is 7.1%. It is lower than that of hospitals of non-existing. The impact level 1 of hospitals of existence of the alternative electricity is 10.7%. It is higher than that of hospitals of non-existence.

Fig. 10 shows a percentage of each capacity of the alternative electricity of hospitals. 42% of the hospitals have no alternative electricity or less than 12 hours of the capacity. A disaster medical care plan requires the capacity of three days in 60% service level. The blackout of the most areas in Hokkaido prefecture continued for 12 hours at least after the earthquake. Therefore, the capacity of 12 hours may be insufficient. Fig. 11 illustrates the impact level in each capacity of the alternative electricity. This figure shows that the impact level decrease in increase of the capacity of the alternative electricity. For example, there is not the impact levels 3 and 4 when the capacity of the alternative electricity is more than 168 hours, that is, one week. On the other hand, the impact level 4 is maximum when the capacity of the alternative electricity is less than 6 hours. Fig. 12 indicates the cumulative recovery percentage of blackout of affected and non-affected hospitals from the blackout. The percentage of affected hospital from blackout increases when the blackout continued more than 12 hours. This means that the capacity of the alternative electricity is less than 12 hours in many hospitals.

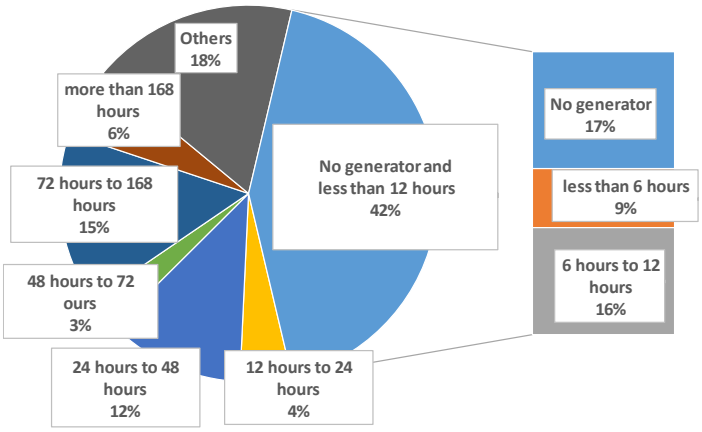

Fig. 10 – Percentage of capacity of alternative electricity of hospitals.

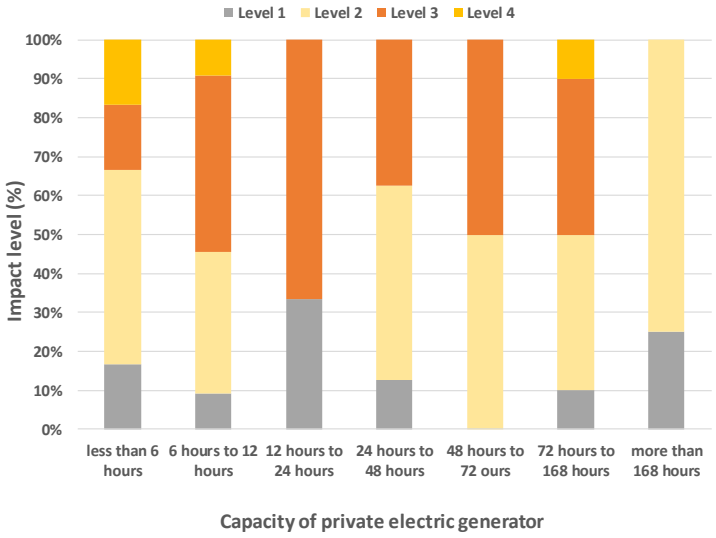

Fig. 11 – Impact level of each capacity of alternative electricity.

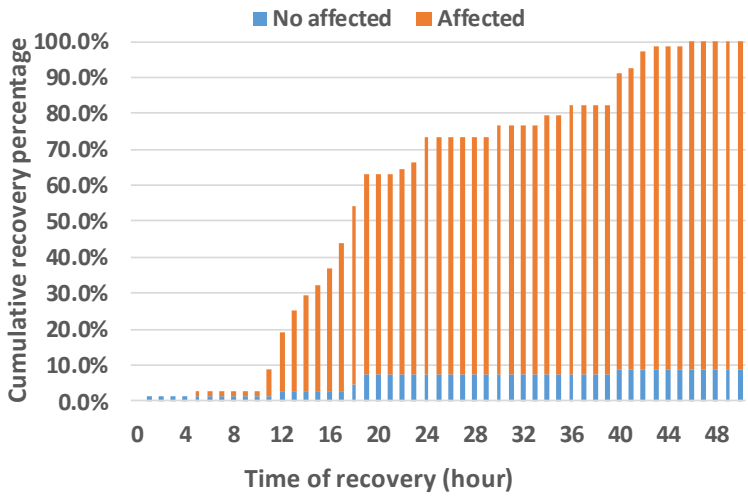

Fig. 12 – Cumulative recovery percentage of blackout in affected and non-affected hospitals.

5. Concluding Remarks

A questionnaire survey for medical institutions affected by the 2018 Hokkaido Iburi-tobu Earthquake in Japan was done and the influence of earthquake damage on medical functions was evaluated. We especially focused on the functional damage to lifeline. The results of this study are summarized as follows.

1) Structure damage of hospitals by the earthquake did not occurred so much, so the performance of hospital was not affected by the structure damage in this earthquake.

2) An impact rate is defined by the number of hospitals affected to the performance by the damage t divided by the number of hospitals suffered by the damage. The impact rate of electricity was 100%, that of water was 50%, and that of gas was 29.4%, respectively.

3) An alternative electricity reduced the effect of power outage on the performance of hospitals. But twelve hours or more of power outage increased negative effects to the performance of the hospital so much**.**

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