

# Health Checkup and Telemedicine System in Post-Disaster Situations

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**Abstract :** Portable Health Clinic (PHC) is a mobile healthcare system comprising medical sensors and health assessment criteria. It has been applied in Bangladesh for the last two years as a pilot program to identify non-communicable diseases. In this study the PHC health assessment criteria are redesigned to deal with emergency cases and healthcare worker insufficiency. A new algorithm makes an initial assessment of age, symptoms, and whether the person is seeing a doctor. These changes will make the turn-around time shorter and will enable reaching the most effected patients more easily. We applied previous data to the new algorithm and simulated the result for tele-medicine. We also tested the operability and turn-around time of the adapted system at the debris flow disaster shelters in Hiroshima, Japan. Changing the PHC health assessment criteria and other solutions such as a list of medicine preparation makes the PHC system switch into an emergency mode more smoothly following a natural disaster.

**Keywords :** disaster, m-health, healthcare informatics, triage, tele-consultation

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## 1. Introduction

Many countries, such as Japan and Bangladesh, experience catastrophic natural disasters. The World Health Organization declared that 58 crisis countries face acute Human Resources for Health (HRH) crisis<sup>1)</sup>. In Bangladesh, 26% population is affected by cyclones, and 70% live in flood-prone regions<sup>2)</sup>. Natural disasters result in casualties and damage medical facilities and the health workforce<sup>3)</sup>. The 2011 Tohoku Earthquake demonstrated the need for disaster management in aspects including healthcare. Although most casualties in the Tohoku Earthquake were because of drowning, the bad living environment in post-disaster shelters worsened the health condition of victims<sup>4)</sup>. Strategies for post-disaster management are urgently required, and mobile healthcare systems may reach disaster victims quickly.

Kyushu University Hospital and Grameen Communications conducted a health management study using information communication technology. The Portable Health Clinic (PHC) with medical sensors provided immediate consultation with the remote doctor over Skype for non-communicable diseases (NCDs). Following consultation, the remote doctor gives the patient an e-prescription. Data collection was conducted in 10 locations of Bangladesh between July 2012 and February 2014<sup>5)</sup>.

However, little is known on the feasibility of introducing PHC into post-disaster areas where the healthcare conditions are different from those in non-disaster areas.

We design a new algorithm and examine the feasibility and risks of post-disaster healthcare management with a general health evaluation targeting disaster-related symptoms caused by trauma, infectious and chronic diseases, and mental disorders. The findings would be useful in making

an emergency mode of PHC to support post-disaster areas in Bangladesh, Japan, and other countries after disasters.

## 2. Methods

### 2.1 Logistics Classification Research

We collected data and performed a literature review on disasters in Bangladesh to understand the risks in post-disaster areas. We collected data from EM-DAT and Asian Disaster Reduction Center and used the keywords "natural disasters," "disease," "healthcare," "impact," "epidemiology," and "shelter" to collect literature through PubMed and Web of Science to classify disaster-related healthcare risks.

### 2.2 Triage protocol using a new logic [Table 1]

The PHC has following devices: weight scales, tape measures, blood pressure meters, glucose meters, body thermometers, pulse oximeters, urine test strips, and hemoglobin meters. Through examinations with these devices, a health assessment can be made. The health assessment logic, called Bangladesh logic (B-Logic), was introduced into all the disease management activities of PHC in Bangladesh. The first checkup using B-logic was provided to 16,741 subjects and after one year, 2361 subjects participated in the second checkup and the systolic blood pressure of these subjects was significantly decreased from an average of 121 mmHg to an average of 116 mmHg ( $P < .001$ ). The results of PHC activities for 2 years demonstrated the benefits of an eHealth checkup and teleconsultation program as an effective health care system in developing countries<sup>5)</sup>.

In B-logic criteria, the results are divided into four stages (green, yellow, orange, and red), and they form a health assessment of Bangladeshis under non-disaster conditions. B-logic criteria do not

address the post-disaster conditions because there is often a shortage of healthcare workers, and the unavailability of medicine is more serious in post-disaster than in non-disaster conditions. Therefore, we designed a triage protocol using B-logic and conducted a series of medical questionnaires on possible symptoms in post-disaster areas. The symptoms are assigned with risk assessment.

### 2.3 Operation Test

To examine the feasibility of the designed triage protocol, an operation test was conducted in chosen areas of Hiroshima City that were affected by a large debris flow in August 2014. This debris flow resulted in many casualties with 74 deaths and 44 injured<sup>6)</sup>. Some victims were still living in disaster shelters in October 2014. We performed an operation test in the post-disaster shelters of Hiroshima on October 25th to better understand their health condition and to classify the operation, suitability, and efficiency of PHC performance in post-disaster areas.

### 2.4 Data Simulation

To verify the effect of the algorithm for disaster, we conducted a simulation with the data collected by the health management study conducted in Bangladesh for past 2 years. In total 16,741 subjects from all over country including both urban and rural areas, have received the health checkup. We applied the new algorithm to the data and simulated how many of the subjects in a non-disaster situation will need tele-consultation with this algorithm.

## 3. Results

### 3.1 Logistics Classification Research Result

The investigation shows that in Bangladesh, floods and cyclones cause destructive damage during and after the disasters. They are the two disasters in the top 10 disasters that affected most people from 1985 to 2014<sup>7)</sup>.

Fever, diarrhea, respiratory problems, and abdominal pain are the most common symptoms in post-disaster

[Table 1] B-logic

	Normal	Caution	Tele-medicine	Tele-medicine
Weist (cm)	Male < 90	90 ≤		
	Female < 80	80 ≤		
Weist / Hip	Male < 0.9	0.90 ≤		
	Female < 0.85	0.85 ≤		
BMI	< 25	25 ≤ < 30	30 ≤ < 35	35 ≤
Systolic BP(mmHg)	< 130	130 ≤ < 140	140 ≤ < 180	180 ≤
Diastolic BP (mmHg)	< 85	85 ≤ < 90	90 ≤ < 110	110 ≤
Fasting BS (mg/dl)	< 100	100 ≤ < 126	126 ≤ < 200	200 ≤
Postprandial BS (mg/dl)	< 140	140 ≤ < 200	200 ≤ < 300	300 ≤
Urine Protein	-	±	+ ≤	
Urine Sugar	-	±	+ ≤	
Urobilinogen	±		+ ≤	
Pulse	60 ≤ < 100	50 ≤ < 60 or 100 ≤ < 120	< 50 or 120 ≤	
Arrhythmia	No		Yes	
Smoke	No	Yes		
Temperature (°C)	< 37	37 ≤ < 37.5	37.5 ≤	
SpO <sub>2</sub> (%)	≥ 96%	93 ≤ < 96	90 ≤ < 93	< 90
Hemoglobin (g/dl)	≥ 12	10 ≤ < 12	8 ≤ < 10	< 8

Bangladesh. Approximately 20–40% of these subjects had diarrhea, which mainly resulted from cholera and rotavirus infections<sup>8,9)</sup>. Chronic stress after natural disasters may also significantly affect cardiovascular risk factors<sup>10)</sup>. People with NCDs are more vulnerable in emergencies and disasters, when emergencies exacerbate NCDs, leading to acute complications<sup>11)</sup>. Natural disasters cause a higher prevalence rate of NCDs and negatively impact people with pre-existing conditions<sup>12)</sup>.

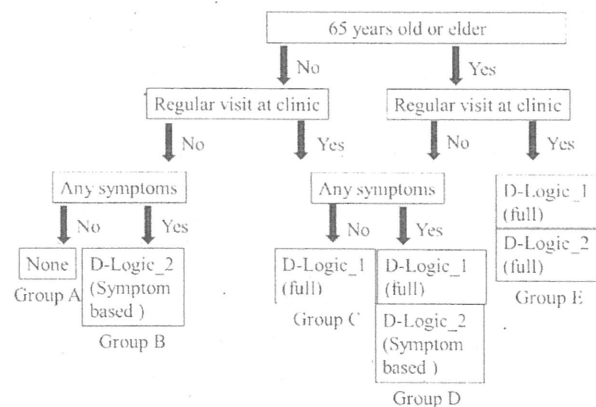
### 3.2 Triage protocol using a new logic

The PHC algorithm was redesigned to target disaster situations. In the Disaster Logic (D-Logic) algorithm, the criteria for teleconsultation were adjusted for fewer people to see a doctor. This adjustment was acceptable in the short term, just after a disaster, to avoid congestion. A new assessment was added into D-logic for better coverage in disaster-related physical and mental health conditions.

D-logic was introduced to provide initial assessments of age and symptoms. Assessments based on sensor data and symptom questionnaire were created for a general examination of healthcare risks in our logistics classification of disasters. With the obtained results of D-logic, the remote doctor will make decision and instructions by Skype and e-prescription.

The D-logic triage was designed in the following steps:

1. Make an initial assessment with three questions shown in [Figure1] for the disaster patients.
2. According to the results of the initial assessment, disaster patients will be divided into five groups with different examinations [Figure1].
3. Following check items and criteria are designed



[Figure1] Initial assessment and Flowchart of D-logic

[Table 2] Adjusted Items in B-logic to constitute D-logic

	Normal	Caution	Tele-medicine	Tele-medicine & Encouragement to visit clinic
Systolic BP (mmHg)	< 140	140 ≤ < 160	160 ≤ < 200	200 ≤
Diastolic BP (mmHg)	< 80	90 ≤ < 100	100 ≤ < 120	120 ≤
Urine Protein	-/±	+	2 + ≤	
Urine Sugar	-/±	+ ≤		
Temperature (°C)	< 37	37 ≤ < 37.5	37.5 ≤	
Number of Fresh Skin lesion	None		None	2 or more
Body Weight Change (kg)	x < ± 1.0	± (1.0 ≤ < 3.0) or unknown	± (3.0 ≤ < 5.0)	± 5.0 ≤

as D-logic\_1 and 2, which are two examinations. D-logic\_1 is based on the sensor measurements. Table 2 shows the adjusted items of D-logic\_1 based on B-logic. The items are adjusted based on B-logic to fit with healthcare worker insufficiency in a post-disaster area. D-logic\_2 will also perform a questionnaire examination with the criteria to decide if the subject needs a teleconsultation with a remote doctor<sup>13)</sup>. Sensors and questionnaire based examination and will be checked based on the result of an initial assessment [Figure 1].

### 3.3 Operation Test

To verify the operation, suitability, and turn-around time of the adapted PHC system to a post-disaster area, we tested the D-logic at the debris flow disaster shelters in Hiroshima, Japan.

We prepared the questionnaires and medical sensors to conduct the examination of two criteria, D-logic\_1 and D-logic\_2, to the victims who were still living in disaster shelters. Three disaster shelters and one area affected by debris flow in the city were chosen for the operation test.

We used three disaster victims as test subjects and used the medical sensors and questionnaires based on D-logic\_1 and D-logic\_2. Some problems and improvements to the procedure were clarified through the operation test as mentioned below.

All the subjects in our limited operation test answered that they did not feel any health problems during the initial assessment. However, through the questionnaires and examinations we found that two subjects showed some abnormalities on the examination results. Though neither of them was aware of abnormalities in their health conditions before we made the examination, one of them had a blood pressure of 158/94 mmHg, whereas the other one had a blood sugar of 150 md/dl two hours after eating. The ages of these two subjects were >65, which indicate a higher risk of NCDs.

We conducted a full examination of D-logic and measured the turnaround time. In total, approximately 15 min on average was taken from the interview and 6 min on average was taken from

the examination by medical examiners. In this operation test, the disaster ended a few months ago, which may be the reason why many victims were not fully cooperative at first. Extra time was needed to communicate with the victims for them to join the test. Health-seeking behavior is poor months after the disaster ends. However, health-seeking behavior is prevalent earlier in post-disaster areas when possible trauma and shelter conditions are considered<sup>14)</sup>.

Among the three subjects, two had trauma due to tumbling on the second day after the debris flow. The debris flow sand deposit increased the chance of slipping. Secondary injuries in a post-disaster area should be considered when responding to the healthcare risks after disasters that cause wet and slippery conditions.

### 3.4 Data Simulation [Figure 2] [Figure 3]

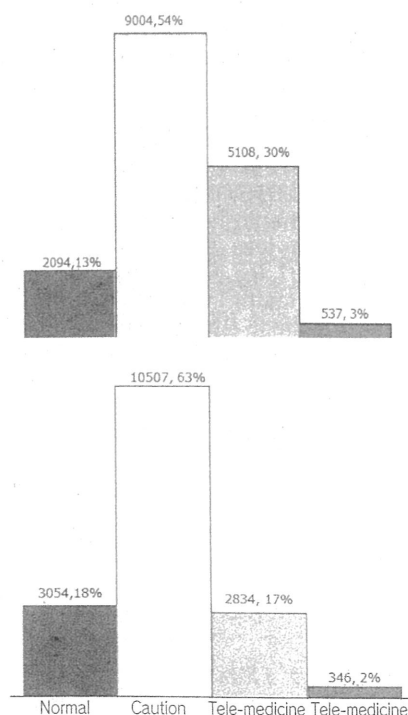
The data of 16,741 subjects is applied to the both algorithm, B-logic and D-logic, to examine how many percent of the subjects are in need of tele-medicine respectively. In [Figure 2], the upper graph shows that 33% of the subjects are triaged by B-logic as in need of tele-medicine by a remote doctor while the lower graph shows that only 19% subjects will be triaged by D-logic as in need of tele-medicine.

Furthermore, of all the subjects there are 1,304 who are over 60 years old. The result of our logistics classification research has shown that the health condition of old people are rather liable to be affected by post-disaster environment. In Figure 3, the simulation shows that 69% of the subjects are triaged by B-logic as in need of tele-medicine by a remote doctor, while 35% of the subjects are triaged by D-logic while as in need of tele-medicine.

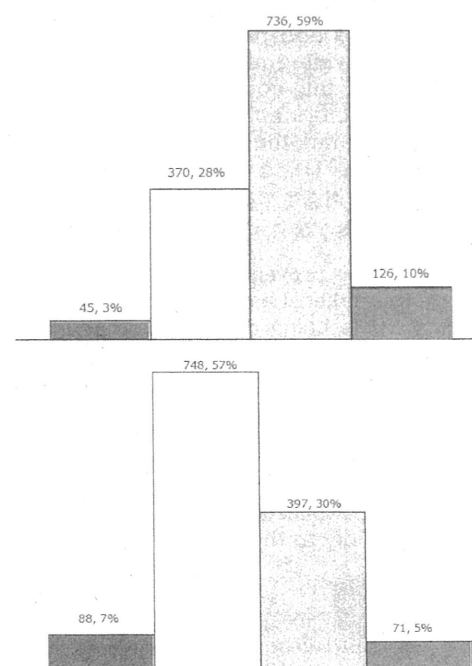
## 4. Discussion

### 4.1 Limitation of the System

Disaster damages may lead to a power outage and network malfunction, and this will affect the PHC consumables. Battery backup may be too limited to cover all patients in a post-disaster area. To relieve



[Figure 2] Simulation Result by B-logic and D-logic



[Figure 3] over 60 yo simulation result by B-logic and D-logic

the situation, an initial assessment can be used to screen the victims with the most health risks and relieve the pressure on consumables, resources, and healthcare worker insufficiency. However, an operation test on a large number of subjects is necessary in the future to improve the efficiency of triage by D-logic.

In Bangladesh, pharmacies and drugstores are common even in rural areas. Para-professionals, pharmacy, and drugstore sales people were the major healthcare providers to disaster-affected people after Cyclone Sidr<sup>15)</sup>. Necessary medicine can be prepared in advance from the drugstores in Bangladesh and help the patients in the worst condition. However, treatment for PHC in Japan is limited to emergency usage. Different preparations should be planned depending on the policies of different countries and situations.

#### 4.2 Further Improvement

According to the results of the data simulation, D-logic decreases the percentage of tele-consultation group to avoid congestion though the adjustment does not lead to threatening condition of subjects in the short term. In post-disaster shelters, D-logic with both disaster-specified algorithm and questionnaire list, can shorten the turn-around time of tele-consultation procedure effectively. However, disasters have impacts on critical infrastructure leading to power outage and network failure. PHC devices are vulnerable to post-disaster power outage and wet conditions. Backup for device consumables and waterproof measurement are necessary for future use of the post-disaster condition. During the operation test in Hiroshima, questionnaires data and examination were manually recorded. To evaluate the effectiveness of D-logic of PHC in the future, follow-up on the health condition of tested subjects will be necessary, as well as the other procedures such as the measuring turn-around time, recording severity assessment from remote doctor after tele-consultation, and creating a control group which does not receive tele-consultation in a real post-disaster situation.

Tele-consultation in this case provides health care to post-disaster subjects mainly through remote doctors' advices and prescription. Therefore, the health care providing ability can be evaluated with the amounts of tele-consultation and turn-around time. The 2 factors above will be measured in the future for evaluating the health care providing ability of this system

#### 5. Conclusion

PHC is a disease prevention program in Bangladesh and has undertaken health checkups for more than two years. It is being developed to reach the low-income people. Its mobility and agility make it easier to be carried into the rural and post-disaster areas. With widespread use in ordinary conditions, the emergency mode can become more suitable and rapidly introduced in post-disaster areas. Existing packages in disaster areas can be switched into emergency mode immediately after the disaster ends to respond rapidly to the post-disaster health risks.

#### References

1) World Health Organization (WHO): The World Health Report 2006 - Working together for health. Geneva: World Health Organization;

- 2006.
- 2) Cash RA, Halder SR, Mushtuq H et al. Reducing the health effect of natural hazards in Bangladesh. *The Lancet*. 2013; 382: 2094-2103.
- 3) Ochi S, Nakagawa A, Lewis J et al. The great East Japan earthquake disaster: distribution of hospital damage in Miyagi Prefecture. *Prehosp Disaster Med*. 2014; 29(3): 245-53.
- 4) Ohkouchi S, Shibuya R et al. Deterioration in regional health status after the acute phase of a great disaster: respiratory physicians' experiences of the Great East Japan Earthquake. *Respir Investig*. 2013; 51(2): 50-5.
- 5) Nohara Y, Kai E, Ghosh P et al. A Health Checkup and Tele-Medical Intervention Program for Preventive Medicine in Developing Countries: A Verification Study. *Journal of Medical Internet Research*, 2014, in press.
- 6) Damage assessment report on the heavy rain of August 19th. Disaster Prevention Center of Hiroshima. [www.pref.hiroshima.lg.jp/uploaded/attachment/139124.pdf](http://www.pref.hiroshima.lg.jp/uploaded/attachment/139124.pdf) Accessed November 21th, 2014.
- 7) Country Report: People's Republic of Bangladesh. Asian Disaster Reduction Center Web site. [http://www.adrc.asia/countryreport/BGD/2013/BGD\\_CR2013B.pdf](http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf). Accessed October 7th, 2014.
- 8) Kunii O, Nakamura S, Abdur R et al. The impact on health and risk factors of the diarrhea epidemics in the 1998 Bangladesh floods. *Public Health*. 2002; 116: 68-74.
- 9) Siddique AK, Baqui AH, Eusof A et al. 1988 Floods in Bangladesh. Pattern of Illness and causes of Death. *J Diarrhoeal Dis Res*. 1991; 9(4): 310-314.
- 10) Jiao Z, Kakoulides SV, Moscona J et al. Effect of Hurricane Katrina on Incidence of Acute Myocardial Infarction in New Orleans Three Years After the Storm. *Am J Cardiol*. 2012; 109: 502-505.
- 11) Demaio A, Jamieson J, Horn R et al. Non-Communicable Diseases in Emergencies: A Call to Action, *PLoS Currents Disaster*. 2013; 5: 1-8.
- 12) Konno S, Hozawa A, Munakata M. Blood pressure among public employees after the Great East Japan Earthquake: the Watari study. *Am J Hypertens*. 2013; 26(9):1059-63.
- 13) Hu M, Sugimoto M, Rebeiro A et al. Mobile Healthcare System for Health Checkups and Telemedicine in Post-Disaster Situations. 15th World Congress on Health and Biomedical Informatics, 2015, Brazil. In press.
- 14) Daniels A, Chapin E, Aspilcueta D et al. Access to health services and care-seeking behaviors after the 2007 Ica earthquake in Peru. *Disaster Med Public Health Prep*. 2009; 3(2): 97-103.
- 15) Jalal U, Robert EM. Socioeconomic factors differentiating healthcare utilization of cyclone survivors in rural Bangladesh: a case study of cyclone Sidr. *Health Policy Plan*. 2014; 29 (7).