MEDINFO 2015: eHealth-enabled Health
I.N. Sarkar et al. (Eds.)

doi:10.3233/978-1-61499-564-7-79

Mobile Healthcare System for Health Checkups and Telemedicine in Post-Disaster Situations

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Abstract

Portable Healthcare Clinic (PHC) is a mobile healthcare system comprising of 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, we adapted PHC to fit post-disaster conditions. 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 affected patients better. We 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:

Paper, Medinfo 2015; Post Disaster; eHealth; mHealth; Teleconsultation; Public Health Informatics.

Introduction

The World Health Organization declared that 58 crisis countries, including Bangladesh, face acute Human Resources for Health (HRH) crisis [1]. Many countries experience catastrophic natural disasters. In Bangladesh, 26% of the population is affected by cyclones, and 70% live in flood-prone regions [2]. Natural disasters result in casualties and damage medical facilities and the health workforce [3]. 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 [4]. 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 Healthcare 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 [5].

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

We 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. After disasters, the findings of this study would be useful for developing an emergency mode of PHC to support post-disaster areas in Bangladesh, Japan, and other countries.

Methods

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.

Revising Triage Rule for Post-Disaster Situation

The PHC has the 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 [5].

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.

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 [6]. 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 conditions and to classify the operation, suitability, and efficiency of PHC performance in post-disaster areas.

Results

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 [7].

As the most frequent disaster in Bangladesh, flood disasters cause deaths from drowning (67.6%), physical trauma (11.7%), heart attack (5.7%), fire (3.6%), electrocution (2.8%), and other (8.6%) [8]. In addition to the direct impact of the disaster, health conditions of post-disaster populations are also affected by poor sanitary conditions of shelters, increasing tobacco abuse, and more stress.

Fever, diarrhea, respiratory problems, and abdominal pain are the most common symptoms in post-disaster Bangladesh. Approximately 20–40% of these subjects had diarrhea that mainly resulted from cholera and rotavirus infections [9-11]. For acute respiratory infections, a moderate increase in risk during the six months after the flood and the subsequent 18 months were found [12]. Chronic stress after natural disasters may also significantly affect cardiovascular risk factors [13]. People with NCDs are more vulnerable in emergencies and disasters, when emergencies exacerbate NCDs, leading to acute complications [14]. Natural disasters cause a higher prevalence rate of NCDs and negatively impact people with pre-existing conditions [15, 16].

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 Figure 1 for the disaster patients.
2. According to the results of the initial assessment, disaster patients will be divided into five groups with different examinations (Figure 1).
3. Following check items and criteria are designed as D-logic_1 and 2, which are two examinations. D-logic_1 is based on the sensor measurements (Table 1). The red items in Table 1 are adjusted based on B-logic to fit with healthcare worker insufficiency in a post-disaster area. Referring to the index of symptoms questionnaire (Table 2), D-logic_2 (Table 3) will also perform a questionnaire examination with the criteria to decide if the subject needs a teleconsultation with a remote doctor. Symptoms in Table 2 will be checked based on the result of an initial assessment (Figure 1). From the data presented in Table 2, scores for each observation in Table 3 can be added to show if there is a minor or major abnormality. As a result, subjects with more than two scores will be required to have a teleconsultation with remote doctors.

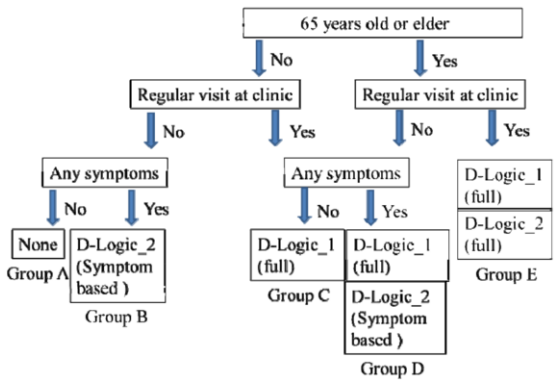

Figure 1 – Initial assessment and Flowchart of D-logic

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 over 65, and this point indicates a higher risk of NCDs.

Table 1 – D-logic_1 (Red parts are the adjusted items based on B-logic, ordinal criteria)

Test	Normal	Caution	Remote medicine	Remote medicine & Encouragement to visit clinic
Body Weight Change (x kg)	x < ±1.0	±(1.0 ≤ x < 3.0) or unknown	±(3.0 ≤ x < 5.0)	±5.0 ≤ x
Blood Pressure (x mmHg systolic BP and y mmHg diastolic BP)	x < 140 (x < 130)	140 ≤ x < 160 (130 ≤ x < 140)	160 ≤ x < 200 (140 ≤ x < 180)	200 ≤ x (180 ≤ x)
	y < 90 (y < 85)	90 ≤ y < 100 (85 ≤ y < 90)	100 ≤ y < 120 (90 ≤ y < 110)	120 ≤ y (110 ≤ y)
Fasting Blood Sugar (x mg/dl)	x < 100	100 ≤ x < 126	126 ≤ x ≤ 200	200 ≤ x
Postprandial Blood Sugar (x mg/dl)	x < 140	140 ≤ x < 200	200 ≤ x ≤ 300	300 ≤ x
Urine test				
Urine Protein	- /± (-)	+ (±)	≥2+ (≥+)	
Urine Sugar	- /± (-)	≥+ (±)	(≥+)	
Urobilinogen	±		+≤ (≥+)	
Pulse Ratio	60 ≤ x < 100	50 ≤ x < 60 or 100 ≤ x < 120	X < 50 or 120 ≤ x	
Arrhythmia	None		Yes	
Number of Fresh Skin lesion	None		None	2 or more
Temperature(Celsius degree)	x < 37	37 ≤ x < 37.5	37.5 ≤ x < 38.5 (37.5 ≤ x)	38.5 ≤ x
SpO2(x %)	x ≥ 96	93 ≤ x < 96	90 ≤ x <93	x < 90
Hemoglobin (x g/dl)	x ≥ 12	10 ≤ x < 12	8 ≤ x <10	x < 8

Table 2 – Examination Item Index for D-logic_2 Check sheet

Symptom		Checksheet Number											
S1	Loss of consciousness	1	31	109									
S2	Depression	2	3	6	7	102							
S3	Flash back	3											
S4	Fever without any symptoms	101											go to S24
S5	Fever with respiratory symptoms	101											go to S11
S6	Fever with gastrointestinal symptoms	101											go to S11
S7	Fever with trauma	101											go to S21,S24
S8	Fever with other symptoms	33	101										
S9	Fatigue	1	2	5	6	7	101	102	103				go to S24
S10	Dizziness	1	4	101	103	105	106	108					
S11	Respiratory symptoms	12	13	14	15	16	17	101	105	107			
S12	Headache	1	4	8	9	31	101	103					
S13	Palpitation	6	17	19	101	105	106	108					go to S24
S14	Chest pain	19	20	103	105	106	107						
S15	Paralysis	1	4	21	22	23	31	103	105	106	107	109	
S16	Nausea or vomiting	7	8	9	10	11	25	31	101				go to S24
S17	Diarrhea	7	8	9	10	11	25	101					go to S24
S18	Stomachache	7	8	9	10	11	25	101					
S19	Abdominal pain	7	8	9	10	11	25	101					
S20	Constipation	11	26										go to S24
S21	Trauma	1	27	28	29	30	31	101					
S22	Other symptoms	33											
S23	Risk of pulmonary thrombosis	32											
S24	Dehydration	5	24	25	32	101	102	103	105				

Table 3 – D-logic_2 (Symptoms based check sheet)

D-logic2 Number	Observation	Normal (score 0)	Minor Abnormality (score 1)	Major Abnormality (score 2)
1	Confusion or loss of consciousness	No	Yes	
2	Sleep disturbance	No	Yes	
3	Flash back	No		Yes
4	Dizziness	No	Yes	
5	Thirsty	No	Yes	
6	General fatigue	No	Yes	
7	Loss of appetite	No	Yes	
8	Nausea	No	Yes	
9	Vomiting	No	Yes, only one time without bloody emesis	Yes, two times or more, or bloody emesis
10	Stomach ache	No	Yes, mild	Yes, severe
11	Abdominal pain	No	Yes, mild	Yes, severe
12	Cough	No	Yes, mild	Yes, severe
13	Nasal congestion	No	Yes	
14	Sore throat	No	Yes, mild	Yes, severe
15	Sputum	No	Yes	
16	Hemoptysis	No		Yes
17	Respiratory distress	No	Yes	
18	Headache	No	Yes, mild	Yes, severe
19	Palpitation	No	Yes	
20	Chest pain	No	Yes, mild	Yes, severe
21	Paralysis	No		Yes
22	Dysarthria	No		Yes
23	Visual disturbance	No		Yes
24	Urination	Normal	Less than normal	Anuria or oliguria (≤2/day) or much more than usual
25	Diarrhea	No	Yes, not watery	Yes, watery
26	Defecation	Normal	Less than normal	Severe (no defecation for more than 5days)
27	Surface injury	No	Yes, mild, and bleeding (-), and pus formation (-) now	Yes, severe, or bleeding or pus formation
28	Swelling	No	Yes, mild	Yes, severe
29	Joint pain	No	Yes, mild	Yes, severe
30	Pain of injury	No	Yes, tolerable without pain reliever	Yes, intolerable without pain reliever
31	Head trauma	No		Yes
32	Staying or sleeping in narrow place	No	Yes	
33	Any other symptoms	No		Yes
101	Fever (Celsius degree)	$x < 37$	$37.0 \leq x < 37.5$	$37.5 \leq x < 38.5$
102	Loss of body weight (kg)	$x < \pm 1.0$	$\pm 1.0 \leq x < 3.0$ or change is unknown	$x \geq \pm 3.0$
103	Systolic blood pressure (mmHg)	$100 \leq x < 140$	$140 \leq x < 160$ or $80 \leq x < 100$	$x < 80$ or $x \geq 160$
105	Pulse rate	$60 \leq x < 100$	$50 \leq x < 60$ or $100 \leq x < 120$	$x < 50$ or $x \geq 120$
106	Arrhythmia	No		Yes
107	Low oxygen in arterial blood (%)	$x \geq 96$	$93 \leq x < 96$	$x < 93$
108	Anemia (x g/dl by Hemoglobin meter)	$x \geq 12$	$10 \leq x < 12$	$x < 10$
109	Japanese Coma Scale	$x = 0$	$x = 1$ or 2 or 3	$x \geq 10$

During the operation test interview, some items were difficult to answer. These items are clearer to the people around the subjects. In the future, the items of the questionnaire can be divided into subjective and objective symptoms. Only the items on subjective symptoms will be questioned, and the examiner or the subjects' family can judge the items on objective symptoms. Other items such as arrhythmia or number of skin lesions were chosen as D-logic_1 and D-logic_2 components, increasing the examination turnaround time.

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. Months after the disaster ends, health-seeking behavior is poor. However, health-seeking behavior is prevalent earlier in post-disaster areas when possible trauma and shelter conditions are considered [17].

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.

Discussion

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 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 [18]. 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.

Further Improvement

Disasters have impacts on critical infrastructure leading to power outrage 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. In the future, PHC will automatically switch from B-logic to D-logic by information technology, and this will result in less turnaround time and more efficiency in post-disaster settings.

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.

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