

Emergency Response Organization through Enterprise Engineering Perspective

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Abstract: Despite the best preparedness of prevention, natural disaster can strike to everyone. Emergency response is a vital action for saving people from loss and damage. We select 2011 Thailand floods, one of the costliest disasters, as our case study. This paper focuses on lifesaving processes including rescue management, temporary evacuation shelter management, and relief management. In order to understand the whole sketch of the emergency response organization, it is necessary to know the essence of the overall processes. The research objective is to find out essential components of the emergency response organization to be guideline for emergency management. It is conducted through analysis and comparison with other cases. Based on literatures and face-to-face interviews with officers from related organizations, the general emergency response activities are visualized by DEMO. The findings can suggest fundamental transactions to policy-and-decision makers to put forward their plan for the upcoming disasters.

1 INTRODUCTION

Nowadays, people in many countries encounter various types of natural disasters. According to the International Disaster Database (<http://www.em-dat.net>), Thailand Floods in 2011 and China's Yangtze River Floods in 1998 are ranked in the top ten of the world costliest natural disasters between 1990-2011. In addition, floods are also shown in seven positions in the top ten most disruptive natural disasters. Flood is the most frequent and common natural disaster occurred around the world (Coppola, 2011). It motivates us to start focusing on this disruptive disaster.

Despite the well-prepared documents in order to prevent the natural disaster, a long period of disappeared disasters can decrease the attention and preparation of people. When a disaster impact, the emergency response is a vital task of the country. The most important thing is people's lifesaving. This study focuses on this crucial phase of the disaster management. Besides a number of disaster manuals, what we should know is a big picture of the overall process. In Thailand, there are some plans published by government, but many of them provide text-based explanation with various detail. This research set the objective to find out the essential components

of the disaster emergency response. Through the perspective of enterprise engineering, this paper uses a 2011 Thailand Floods case to analyze the emergency response of flood disaster and visualizes its ontological models. The models have been revised according to the comments from the actual officers who participated in the processes. In addition, we also make a comparison with previous literatures.

This research makes contribution in both academic and practice aspects. As for academia, this paper performs a thorough study of disaster emergency management issues using DEMO (Design and Engineering Methodology for Organizations). The proposed models can be used as reference models to be expanded for future study. This is also one of the first empirical studies using DEMO on the emergency response management in large-scale natural disaster in developing country (i.e., Thailand). As the research objective is to visualize the emergency response organization and search for necessary components, it can be used for ordinary people, policy makers, or related-role persons to easily understand the essence of the emergency response in disaster. The findings can support the decision maker to create the plan for the upcoming disasters.

The next section mentions our approach, the concept of the enterprise engineering and a selected modeling language, DEMO. The third section reviews previous studies. The fourth section explains the background of emergency response in Thailand. The fifth section describes data collection and data analysis. Finally, the last section explains the discussion and conclusion.

2 ENTERPRISE ENGINEERING AND DEMO

2.1 Enterprise Engineering

Following the first wave of data systems engineering and the second wave of information systems engineering, it is the era of enterprise engineering (Dietz and Hoogervorst, 2008). Enterprise refers to “all kinds of organized activity” (Dietz and Hoogervorst, 2012) such as government agencies, private companies, academic institutes, and projects, etc. It is an interdisciplinary field focusing on investigation of each aspect of the enterprise, including business process, information flow, and organizational structure (Dietz, 2006). Dietz and Hoogervorst (2012) concluded from a century of enterprise development that there are three objectives of the development: “employee empowerment”, “mastering complexity”, and “unity and integration”. As a result, they proposed the principles of enterprise engineering, which consist of “distributed operational responsibility”, “transaction based organization”, “actor based modularity”, “technology independent essence”, “function construction alternation”, “strategy-operation alignment”, and “distributed governance responsibility” (Dietz and Hoogervorst, 2012). Dietz and Hoogervorst (2012) also mentioned that while most of the current modeling tools (e.g., BPMN) cannot achieve the enterprise engineering principles, DEMO has capability to demonstrate the validity of some principles.

2.2 DEMO

DEMO is an enterprise engineering modeling language for analyzing and visualizing the business processes in order to understand the essence of the organization (Dietz, 2006; Dietz and Hoogervorst, 2008, 2012). DEMO was developed by Prof. Dietz. The essential model of DEMO can be described within an A4 or A3 size paper, which other current

modeling methodologies cannot reach this abstraction level (Dietz and Hoogervorst, 2008). Until now, DEMO has been used to study in various areas and cases (e.g., Barjis (2009), Mongula (2009), Op ‘t Land et al. (2009), Tang et al. (2012), Yoshie (2012), Yoshie and Iijima (2012)). According to Dietz (2006), DEMO contains the ontological aspect models (i.e., high-level-abstraction model) and a method for development of those aspect models. As shown in Figure 1, the ontological aspect models consist of “Construction Model”, “Process Model”, “Action Model”, and “State Model” (Dietz, 2006). The Construction Model can explain the identified transaction types and the associated actor roles. It is the most concise model among the aspect models. Construction model is considered as a “white-box model”, as same as the “essential (ontological) model of an enterprise” (Dietz and Hoogervorst, 2012).

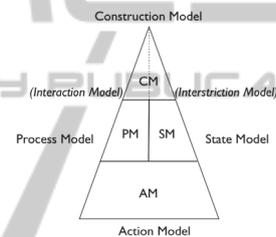


Figure 1: Ontological Aspect Model (Dietz, 2006).

According to Dietz (2006), there are two models embedded in the Construction Model: “Interaction Model” and “Interstriction Model”. While the Interaction Model shows “the active influences between actor roles”, the Interstriction Model shows “the passive influences between actor roles”.

In the Interaction Model, the Actor Transaction Diagram or ATD is a collection of the related transaction type. The legend of ATD is shown in Figure 2. Actor role is an operating unit of an organization. The composite actor role is the environment actor role. The initial link connects the actor who is the initiator to the transaction type. The executor link connects the actor who is the executor to the transaction type. The line highlighted by grey color is the boundary, which is used to separate the composition and the environment (Dietz, 2006).

The Transaction Result Table (TRT) is a table that shows the specification of the transaction type. TRT includes the information of transaction type, transaction type name, and the result of transaction type (Dietz, 2006).

The pizzeria case (Dietz, 2006) is frequently used to describe the concept of DEMO. The ATD of the pizzeria case is shown in Figure 3 while the TRT

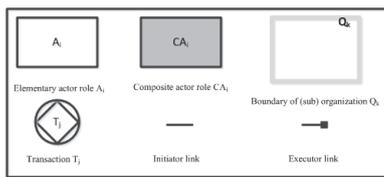


Figure 2: Legend of ATD (Dietz, 2006).

The pizzeria case (Dietz, 2006) is frequently used to describe the concept of DEMO. The ATD of the pizzeria case is shown in Figure 3 while the TRT is shown in Table 1. For instance, when customer wants to purchase pizza, the customer requests a completer to complete the transaction for that purchase. Then, the completer requests a baker to prepare baking the pizza. The Interaction Model can be described in terms of ATD and TRT such as in TRT, transaction ‘T01 completion’ has a result type as ‘R01 purchase P has been completed’; in ATD, the CA01 customer is an initiator of the transaction ‘T01 completion’ and A01 completer (of the pizzeria) is the executor of this transaction.

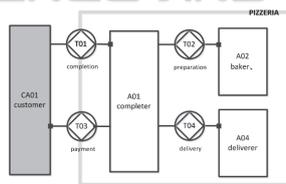


Figure 3: ATD of pizzeria case (Dietz, 2006).

Table 1: TRT of Pizzeria Case (Dietz, 2006).

Transaction type	Result type
T01 completion	R01 purchase P has been completed
T02 preparation	R02 purchase P has been prepared
T03 payment	R03 purchase P has been paid
T04 delivery	R04 purchase P has been delivered

ATD and TRT are used to visualize in our case study. To make it simple and easy to understand with the real practice/functional type, we also show the actual existing initiators and the actual existing executors in the TRTs.

3 LITERATURE REVIEWS

3.1 Flood Control Domain in the Netherlands and USA

Mongula (2009) studied and developed enterprise ontology to describe how flood control domain is

operated. She identified the essential operations and showed the interrelationships between the identified essential operations. Her study demonstrated how to develop general models using DEMO. Her findings show that most of the actors (i.e., initiator and executor) can be mapped to the real existing organization in both the Netherlands and the United States, except only some differences in terms of relationship (e.g., a hierarchical relationship in US and a horizontal relationship in the Netherlands).

3.2 Emergency Response from Earthquakes in Japan

Yoshie (2012) and Yoshie and Iijima (2012) studied the emergency response in Japan through the interviews and document reviews of Hanshin-Awaji Earthquake in 1995 and Niigata-Chuetsu Earthquake in 2004. DEMO was used to identify the essential operations and develop the general model. Although two earthquakes occurred in different time periods, different cities, different local governments, there were common operations and some optional operations depended on “scale of damage”, “characteristics of the region”, and “timing of the disaster”.

Those mentioned studies focus on disaster management in the developed countries and the countries frequently encountered the natural disasters. Nevertheless, there is a limited study focused on developing countries, especially some countries which have less experience in large natural disaster. Although some countries found the low possibility of flood, but since the current global warming and various environmental impacts on our beloved planet, it is necessary for all countries to pay attention to it. This study focuses on this point and tries to fill this gap.

4 2011 THAILAND FLOODS

During the floods, Thai government set up Flood Relief Operation Center (FROC) to be a center for coordinating the request and delivery of aid (FROC, 2012). For the response of floods, the army, naval, and air force personnel were assigned to flood-related efforts including focusing on water management, care and assistance for people in needs, managing relief supplies and supporting other organizations. Despite many organizations helped and supported at that time, the soldiers seems to be main executor in the emergency response due to the large number of soldiers and their prompt

equipment.

Many places were assigned to be temporary evacuation shelter such as universities (e.g., Thammasat University), schools, temples, and even airport and government complex center.

The relief was donated and supported by both public and private sectors, including overseas (e.g., Japan).

In this paper, among various plans in the response phase listed by Thailand’s Office of the National Water and Flood Management Policy (2012), due to the importance, we selected to focus on rescue management, temporary evacuation shelter management, and relief management, which are the vital activities directly related to the life of people.

related officers who played related roles in 2011 Thailand Floods via e-mails. We explained our models and discussed for the correctness, completeness, findings, and suggestion. The models in this paper have been revised according to their comments.

5.2 Analysis of Rescue Management

The ATD can be seen in Figure 4 and the TRT is shown in Table 2.

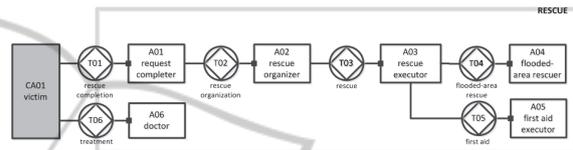


Figure 4: ATD of rescue management.

5 DATA COLLECTION AND ANALYSIS

5.1 Data Collection

The interviews were conducted in Thailand during September 2012, together with the document collection. The interviews and documents were mainly in Thai language. We conducted the face-to-face oral interviews with thirteen officers from related organizations with flood (e.g., Royal Thai Army (RTA), Royal Thai Air Force (RTAF), Bangkok Metropolitan Administration, Khukhot Municipality). Since all of the interviewees encountered the real experience of Thailand Floods situation, we aim to find out the real processes from their experience. The semi-structured interviews were conducted. The questions were set to focus on the whole image and continued with the open discussion to gather the detail of each transaction. While each specific area has different detail in some transactions, we requested the interviewees to provide the general information for us. The examples of question consist of “What kind of process or activity did your organization have during 2011 Thailand Floods?”, “Let’s assume that [transaction] has been done, what is the next step?”, “Who was the initiator of that transaction/activity?”, etc. As mentioned, we focus on three plans of the response phase, which are directly related to the life of people during the disaster. We examined in contrast and similarity with the previous researches (Mongula, 2009; Yoshie, 2012; Yoshie and Iijima, 2012). The comparison went through the ATD and TRT. The first version models were sent to the

Table 2: TRT of rescue management.

Transaction type	Result type	Actual initiator	Actual executor
T01 rescue completion	R01 <i>rescue R for victim V has been completed</i>	Victim	FROC, call center (pub./pvt.)
T02 rescue organization	R02 <i>rescue R for victim V has been organized</i>	FROC, call center (pub./pvt.)	Soldier base, Found., volunteer
T03 rescue	R03 <i>rescue R for victim V has been executed</i>	Soldier base, Found., volunteer	Commanding center leader (or member), volunteer
T04 flooded-area rescue	R04 <i>flooded-area rescue FR of rescue R for victim V has been executed</i>	Commanding center leader	Public service unit
T05 first aid	R05 <i>first aid of rescue R for victim V has been executed</i>	Commanding center leader	Corpsman (or doctor)
T06 treatment	R06 <i>treatment T of rescue R for victim V has been executed</i>	Victim	Doctor

One problem of the actor role was found in the rescue management. In the real situation, some

victims sent requests to many available call centers (actor role: request completer, A01). Then, the duplicated requests were executed by different route of executors (e.g., RTA, RTAF, private organization, volunteer) in the next transaction (T02). It implies the lack of information sharing among organizations and the duplicated actual executors.

Table 3: Comparison of transactions in rescue management.

Case	Transaction
Thailand floods	-Rescue completion -Rescue organization -Rescue -Flooded-area rescue -First aid -Treatment
Great Hanshin-Awaji Earthquake (Yoshie, 2012)	-Rescue and search -Dead-body management -Coffin procurement -Autopsy -Identification -Missing-people consulting -Consultation-system establishing -Patrol enforcement
Niigata-Chuetsu Earthquake (Yoshie, 2012)	-Rescue and search -Dead-body management -Patrol enforcement
The Netherlands (and USA) floods (Mongula, 2009)	-Decide evacuation -Complete evacuation -Mobilize evacuation resource -Implement evacuation -Cordon off evacuated area -Cordon off arrangement -Mobilize cordon off

The comparison of transactions is shown in Table 3. According to the Great Hanshin-Awaji case, there are eight transactions, while Niigata-Chuetsu case has only three transactions. Meanwhile, the Netherlands case shows seven transactions. Rescue management in Thailand seems to focus on rescuing victim from their residences, meanwhile two Japan cases focus on searching for dead bodies, and the Netherlands and USA focus on implementing evacuation and cordon off the area.

5.3 Analysis of Temporary Evacuation Shelter Management

The ATD can be seen in Figure 5 and the TRT is shown in Table 4.

As shown in Table 5, by comparing between the shelter management of Thailand and Japan cases, most of the transactions are similar. Only a few transactions cannot be seen in Japan cases such as

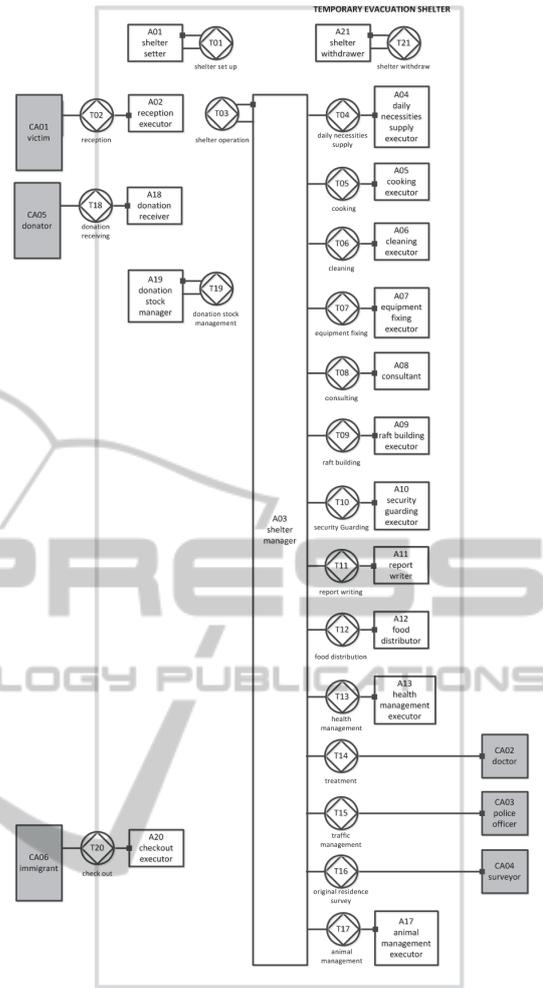


Figure 5: ATD of temporary evacuation shelter management.

raft building, traffic management, while hotel usage support is on the vice versa. As for the Netherlands (and USA), there are four transactions: “take shelter-care measure”, “shelter set up”, “mobilize shelter-care resource”, and “implement shelter-care measure”.

Table 4: TRT of temporary evacuation shelter management.

Transaction type	Result type	Actual initiator	Actual executor
T01 shelter set up	R01 shelter <i>S</i> has been set up at Place <i>P</i>	Camp chief	Camp chief
T02 reception	R02 reception <i>R</i> for victim <i>V</i> has been executed to be immigrant <i>I</i> at shelter <i>S</i>	Victim	Shelter co-ordinator

Table 4: TRT of temporary evacuation shelter management (Cont.).

T03 shelter operation	R03 <i>the shelter S has been operated</i>	Camp chief	Camp chief member)
T04 daily necessity supply	R04 <i>daily necessity supply D has been executed at shelter S</i>	Camp chief	Army, volunteer, relief center
T05 cooking	R05 <i>cooking C at shelter S has been executed</i>	Camp chief	Shelter staff, volunteer
T06 cleaning	R06 <i>cleaning CL at shelter S has been executed</i>	Camp chief	Shelter staff, volunteer
T07 equipment fixing	R07 <i>equipment E at shelter S has been fixed</i>	Camp chief	Shelter staff, volunteer
T08 consulting	R08 <i>consult C at shelter S has been executed</i>	Camp chief	Shelter staff, volunteer
T09 raft building	R09 <i>raft R at shelter S has been built</i>	Camp chief	Shelter staff, volunteer
T10 Security guarding	R10 <i>security at shelter S has been guarded</i>	Camp chief	Shelter staff, volunteer
T11 report writing	R11 <i>report R at shelter S has been written</i>	Camp chief	Shelter staff
T12 food distribution	R12 <i>food F at shelter S has been distributed</i>	Camp chief	Shelter staff, volunteer
T13 health management	R13 <i>health management at shelter S has been executed</i>	Camp chief	Shelter nurse shelter staff, volunteer
T14 treatment	R14 <i>immigrant I at shelter S has been treated</i>	Camp chief	Doctor
T15 traffic management	R15 <i>traffic at shelter S has been managed</i>	Camp chief	Police officer
T16 original residence survey	R16 <i>original residence of immigrant I at shelter S has been surveyed</i>	Camp chief	Army, police officer, civil protection volunteer
T17 animal management	R17 <i>animal A at shelter S has been managed</i>	Camp chief	Shelter staff, Volunteer
T18 donation receiving	R18 <i>donation D at shelter S has been received</i>	Donator (indiv./mfg./org.)	Donation manager

Table 4: TRT of temporary evacuation shelter management (Cont.).

T19 donation stock management	R19 <i>donation stock DS at shelter S has been managed</i>	Donation stock manager	Donation stock manager
T20 check out	R20 <i>immigrant I at shelter S has been checked out</i>	Immigrant	Shelter coordinator
T21 shelter withdraw	R21 <i>shelter S has been withdrawn</i>	Camp chief	Camp chief

Table 5: Comparison of transactions in temporary evacuation shelter management.

Case	Transaction
Thailand floods	-Shelter set up -Reception -Shelter operation -Daily necessity supply -Cooking -Cleaning -Equipment fixing -Consulting -Raft building -Security guarding -Report writing -Food distribution -Health management -Treatment -Traffic management -Original residence survey -Animal management -Donation receiving -Donation stock management -Check out -Shelter withdraw
Great Hanshin-Awaji Earthquake and Niigata-Chuetsu Earthquake (Yoshie and Iijima, 2012)	-Shelter set up -Evacuee reception -Evacuee checkout -Shelter operation -Hotel usage support -Daily necessities supply -Cooked food distribution -Health management -Animal protection [management] -Volunteer support -Shelter withdraw -Request collection -Mental health care
The Netherlands (and USA) floods (Mongula, 2009)	-Take shelter-care measure -Shelter set up -Mobilize shelter-care resource -Implement shelter-care

5.4 Analysis of Donation/Relief Management

The ATD of the donation/relief management can be seen in Figure 6 and the TRT is shown in Table 6.

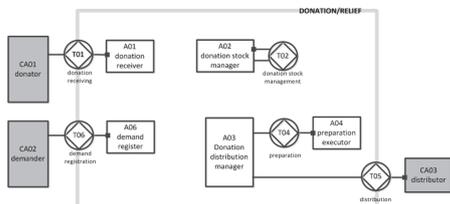


Figure 6: ATD of donation/relief management.

Table 6: TRT of donation/relief management.

Transaction type	Result type	Actual initiator	Actual executor
T01 donation receiving	R01 <i>donation D has been received</i>	Donator (indiv./org.)	Relief center
T02 donation stock management	R02 <i>donation stock DS has been managed</i>	Relief center manager	Relief center manager
T03 preparation	R03 <i>the preparation has been prepared</i>	Relief center manager	Relief center staff
T04 demand receiving	R04 <i>demand DM has been received</i>	Victim, Rescuer	Call center (pub./pvt.)
T05 distribution	R05 <i>relief-supply bags for demand DM have been distributed</i>	Relief center manager	Army, rescuer, Private organization

While Thailand’s donation management consists of donation receiving, donation stock management, preparation, demand receiving, and distribution. Japan cases show donation-related transactions in food-and-necessary-goods guarantee process. Those transactions consist of demand receiving and distribution. Unfortunately, the information about donation management is not available in the Netherlands (and USA) case.

6 DISCUSSION AND CONCLUSIONS

This research studies and analyzes the emergency response in flood disaster by using 2011 Thailand

Floods as a case study. DEMO is our selected modeling language in this study. It provides a very compact form that describes abstraction and clear definition of authorities and responsibilities. As a result, three models have been drawn by ATD and TRT to show the essence of those processes in the compact form. According to the comments from the related officers after we explained our models, they mentioned that our models provide easy-to-understand and clear concept of emergency response organization. By applying DEMO, we can obtain the compact model that explains the whole sketch of the organization. The discussion of our findings will be provided in this section.

First, the rescue management shows various different points among different types of disaster and different countries. The first difference is the more focus on dead-body management in the earthquake due to the characteristics of the disaster, which has high possibility to immediately cause a large number of deaths while the large-scale floods have less chance. As for the aspect of the difference between Thailand and the Netherlands (and USA), the large-scale flood has fewer chances to happen in Thailand than the Netherlands. According to the interviews, we found that many Thai people, especially in metropolitan area, still stayed in their residences (e.g., second or third floor, roof of the house) instead of evacuating since the early warning announcement, because they had no experience and could not imagine and believe that the high-level water would encounter their homes. As a result, Thailand needs to provide a number of transactions that focus on rescuing the victims from their residences, providing first aid, and transferring patient, instead of evacuation in the early stage and cordon off evacuated area like the Netherlands and USA. Moreover, by applying DEMO, we can understand the problem of actor role (i.e., duplicated actual executors) clearer.

Second, surprisingly, the shelter management shows only a few differences between the earthquake cases in Japan and the flood case in Thailand. Thus, this result can suggest the main components of shelter management. A few differences appear only in some specific transactions such as raft building. It can interpret in the aspect of disaster characteristic culture. The early Thai settlement tended to establish near canals and rivers due to the livelihood of inhabitants developed mainly on water (Chaichongrak et al., 2002). The culture and lifestyle seem to influence the specific transaction when there was disaster.

Third, from both Thailand and Japan cases, the common transactions of donation management include donation receiving and demand receiving. Thailand focuses on having the center of donation. There were many public and private donation centers during that time. Each center can understand the need of people by receiving their demands.

In summary, it is necessary to pay attention to the type of the disaster together with the experience of the country. As for flood disaster in less-experienced area, it is suggested to include request completion, rescue organization, rescue, flooded-area rescue, first aid, and treatment as transactions.

For the temporary evacuation shelter management, regardless the activities for specific disaster, its common components consist of shelter set up, reception, shelter operation, daily necessary supply, cleaning, security guarding, report writing, food distribution, health management, treatment, animal management, check-out, and shelter withdraw. In line with Coppola (2011), the shelter management can be set the guideline with common components for most type of the disasters.

Lastly, as for the donation or relief management, the policy maker should consider the nature of country and disaster. The public and private sectors are suggested to think of the feasibility to manage the donation.

Despite reaching our research objective to find the necessary components of emergency response management, this research can be interpreted in terms of limitations. First, the geographical, policy, and experience specification in Thailand and the comparative studies may not generalize the model in some specific aspects. Second, it is still considered as a small number of comparisons in this study. Third, although we selected three lifesaving important activities to analyze, there are other activities needed to examine for the policy makers.

For further study, it is possible to analyze more cases of emergency response in order to create the more general models and find out the similarities and differences between more and less experienced countries, and between different geographical and cultural areas. Other activities of the emergency response can be further investigated. The future study also can be expanded to compare these models with other approaches (e.g., BPMN, Petri nets, Responsibility Modeling) or considering other interesting quantitative dimension (e.g., cost, time).

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