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EBOLA VIRUS DISEASE PREVENTION - A PROBLEM SOLVING STRATEGY BASED ON SARS CASE STUDY FROM TAIWAN

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ABSTRACT

In the first half of the year 2003, the whole world was seriously panicked by SARS, the Severe Acute Respiratory Syndromes. Taiwan was also heavily stricken. While the public in Taiwan was run over by the fear of this unprecedented disaster, the key factors contributing to the ineffective control of the epidemic was identified to be a series of fault decisions made by the panic-stricken official. Nowadays, based on the report of WHO Ebola Response Roadmap Update, a total of 8399 confirmed, probable, and suspected cases of Ebola virus disease (EVD) have been reported in seven affected countries (Guinea, Liberia, Nigeria, Senegal, Sierra Leone, Spain, and the United States of America) up to the end of 8 October. There have been 4033 deaths. In order to provide a problem solving strategy for well managing this potential crisis by government, this study tries to use the concept of Case Based Reasoning (CBR) to apply a case study of SARS epidemic. One important question is often asked: what would have happened if the disease control officer had competent problem solving skills and had timely reacted in line with this epidemic development? It is our task to simulate the problem solving process in the SARS war by deploying the Theory of Constraints (TOC) Problem Solving Model. We also discuss and demonstrate some of findings about TOC application in problem solving.

Key words - Ebola virus disease, SARS, Problem Solving, Theory of Constraints, Crisis management

1. INTRODUCTION

1.1 Ebola Virus Disease Introduction

On March 21, 2014, the Guinea Ministry of Health reported the outbreak of an illness characterized by fever, severe diarrhea, vomiting, and a high case-fatality rate (59%) among 49 persons. Specimens from 15 of 20 persons tested at Institut Pasteur in Lyon, France, were positive for an Ebola virus by polymerase chain reaction. Viral sequencing identified Ebola virus (species Zaïre ebolavirus), one of five viruses in the genus Ebolavirus, as the cause. Cases of Ebola viral disease (EVD) were initially reported in three southeastern districts (Gueckedou, Macenta, and Kissidougou) of Guinea and in the capital city of Conakry. By March 30, cases had been reported in Foya district in neighboring Liberia (1), and in May, the first cases identified in Sierra Leone were reported. As of June 18, the outbreak was the largest EVD outbreak ever documented, with a combined total of 528 cases (including laboratory-confirmed, probable, and suspected cases) and 337 deaths (case-fatality rate = 64%) reported in the three countries. The largest previous outbreak occurred in Uganda during 2000-2001, when 425 cases were reported with 224 deaths (case-fatality rate = 53%). The current outbreak also represents the first outbreak of EVD in West Africa (a single case caused by Taï Forest virus was reported in Côte d'Ivoire in 1994 [3]) and marks the first time that Ebola virus transmission has been reported in a capital city [26].

On March 23, 2014, the World Health Organization (WHO) was notified of an outbreak of Ebola virus disease (EVD) in Guinea. On August 8, the WHO declared the epidemic to be a "public health emergency of international concern." [12]

By September 14, 2014, a total of 4507 probable and confirmed cases, including 2296 deaths from EVD (Zaire species) had been reported from five countries in West Africa--Guinea, Liberia, Nigeria, Senegal, and Sierra Leone. We analyzed a detailed subset of data on 3343 confirmed and 667 probable Ebola cases collected in Guinea, Liberia, Nigeria, and Sierra Leone as of September 14 [28].

A total of 8399 confirmed, probable, and suspected cases of Ebola virus disease (EVD) have been reported in seven affected countries (Guinea, Liberia, Nigeria, Senegal, Sierra Leone, Spain, and the United States of America) up to the end of 8 October. There have been 4033 deaths. Following the WHO Ebola Response Roadmap structure, country reports fall into two categories: 1) those with widespread and intense transmission (Guinea, Liberia, and Sierra Leone); and 2), those with an initial case or cases, or with localized transmission (Nigeria, Senegal, Spain, and the United States of America). An overview of the situation in the Democratic Republic of the Congo, where a separate, unrelated outbreak of EVD is occurring, is also provided [27].

31 October 2014 - WHO has conducted a formal review of personal protective equipment (PPE) guidelines for healthcare workers and is updating its guidelines in the context of the current Ebola outbreak. The updated guidelines aim to clarify and standardize safe and effective PPE options to protect health care workers and patients, as well as provide information for obtaining PPE during the outbreak [1].

These data indicate that without drastic improvements in control measures, the numbers of cases of and deaths from EVD are expected to continue increasing from hundreds to thousands per week in the coming months [12].

In order to provide a problem solving strategy for well managing this potential crisis, this study tries to use the concept of Case Based Reasoning (CBR) to apply a case study of SARS (Severe Acute Respiratory Syndromes) epidemic below.

1.2 SARS case introduction

A non-official report from Guangdong Province, China, dated November 16, 2002 marks the outbreak of a respiratory illness, called atypical pneumonia. In early 2003, SARS heavily attacked eastern Asia, including Taiwan. Several major cities, including Toronto, Hong Kong, Beijing, Singapore, Hanoi etc. are also affected. Until July 14, 2003, SARS claimed 813 lives worldwide [3, 28].

During the period, 671 cases were reported and 84 lives were claimed in Taiwan. Several hospitals were shut down due to in-house infection. Schools were closed to reduce the risk of infection among students. Both the domestic business and international trade were seriously damaged. A total economic loss of ca. US$ 5.4 billion has been estimated [3, 28].

While the SARS was totally new to the world, not only the origin of the disease and the mode of transmission were scarcely known, the effective means for diagnosis and medical remedy were yet to be developed. Incorrect or conflicting information was spread through various media. The medical supplies ran into catastrophic shortage due to immoral hoarding for speculation. Yet, worst of all, a series of fault decisions were made by the panic-stricken officials, which further flamed up the fear of the citizens and ran Taiwan into an unprecedented disaster.

Although Taiwan was finally removed from the WHO’s list of infected areas on July 5, 2003, it was widely speculated that the SARS may reappear when the ambient temperature falls in the cool seasons. It is feared that an even more serious disaster may take place if no preventive actions are taken. As anticipated, SARS did reappear and stroke cities including Singapore, Beijing and Taipei in early 2004. Ever since the first occurrence of SARS, how to establish a thorough and effective crisis management program has become a worldwide concern.

Some important questions are often asked: What would have happened if the disease control officers had competent problem solving skills at the beginning? What if comprehensive process was followed and appropriate actions were timely taken in line with the development of the epidemic? In order to address these questions, we pretend to take the cap of the chief commander of the SARS war in Taiwan, and attempt to encounter with the problems as mentioned above and to break the deadlock by making use of the Theory of Constraints (TOC) problem solving model. We are to simulate the process by utilizing the data and observations surrounding the events appeared in the local newspapers in Taiwan.

2. THE PROBLEM SOLVING MODEL AND THEORY OF CONSTRAINTS

Kepner & Tregoe defined "Problem Solving" as the activity related to changing the AS IF state to the TO BE state [13]. Marston et al. [15] and Chang & Wang [4] defined "Model" like a program used for describing system operation. "Problem Solving Model (PSM)" is used for not only solving problems by serial comprehensible processes; but also for monitoring, evaluating and managing them by problem solvers.

A comparison approach for both expert and novice on analyzing and using information in problem solving has revealed three significant differences [2,10]: (1) An expert is more likely to spend more time on the information collection; (2) An expert is more likely to integrate the related components of their familiar and subjected knowledge to link with the information; (3) During problems classification, an expert is more likely to use and apply the underlying principles on the constructed problem, hereby a novice is more likely to use and apply surface features. The most important thing is how to proper use the appropriated PSM which can identify a problem-solving expert from a novice.

The TOC problem solving model is developed by Eliyahu M. Goldratt in mid-1970s [6,21,29]. Goldratt used a scientific method to create management concept, it has been proven to provide great value for industry. Moreover, Goldratt presented the scientific method by his own expression to construct TOC thinking processes by using common sense. This problem solving process follows the form of TOC thinking processes and a set of five logic tree diagrams of Theory of Constraints [6,16,18,25].

Basically, the Theory of Constraints is talking about change and what's the extent to influence change. The TOC is a group of management principles which helps to identify obstacles for one's goal(s) and how to do the change in order to eliminate them [24,25,26]. For developing an effective output from the TOC thinking processes, Goldratt created three fundamental questions as (1) What to Change? (2) What to change to? (3) How to cause the change? And there is strong linkage between these three questions and five logic trees [6,7,18,24,25,26]. The detailed is shown as Table I:

Table 1.TOC Thinking Processes & Logic Trees

Key Question	Intermediate Objective	Logic tree
What to change?	Identify core problems and find out root causes.	1. Current Reality Tree (CRT)
What to change to?	Eliminate the core problem starting with an objective to search for solution.	2. Evaporating Cloud Tree (EC)(for use with conflicts) 3. Future Reality Tree (FRT)
How to cause the change?	Identify obstacles to implement and devise detailed plans for overcoming these obstacles.	4. Prerequisites Tree (PT) 5. Transition Tree (TT)

3. A CASE STUDY ON SARS IN TAIWAN BY APPLYING TOC

From this case study, we develop the five TOC logic trees by basic analysis tools. They are linking with the following 4-step process, which was extracted from the generalized problem solving process: Step-1 is Problem finding, Step-2 Idea finding, Step-3 Obstacle finding, Step-4 Solution finding.

3.1. Step-1: Problem Finding

In order to encounter the SARS war effectively, the first priority is to clearly define and correctly identify the problem under current situation. Following are the major events occurred in the SARS epidemic disaster in Taiwan.

Date	Major events
2002.11.16	First known case of atypical pneumonia occurs in Guangdong Province, China.
2003.02.11	WHO receives SARS outbreak report from China government.
2003.03.08	Businessman Chin is infected with SARS and returns from China.
2003.03.26	Six employees of Jung-Ding Co. are infected with SARS and return from China.
2003.03.28	Doctor Tsai of NTU Hospital is infected with SARS from Chin's family.

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2003.04.11	Two crews of China Airlines are infected with SARS, all passengers on the same flight are quarantined.
2003.04.17	Researchers of Hong Kong University announce that SARS is generated from a new corona virus with no vaccine so far.
2003.04.22	Seven medical practitioners of Ho-ping Hospital get infected by group due to hiding of epidemic.
2003.04.24	Ho-ping Hospital & schools in Taipei are closed, more than 5,000 people quarantined.
2003.04.28	First SARS death case occurs at Chinese Medical College Hospital (Taichung).
2003.04.30	Jen-Chi Hospital is closed due to SARS outbreak.
2003.05.02	First death case of medical practitioner occurs at Ho-Ping Hospital (Taipei).
2003.05.10	SARS spreads out to Wan-Hwa District (Taipei).
2003.05.16	SARS spreads over various areas of Taiwan.
2003.06.06	Group infection occurs in Yang-Min Hospital (Taipei).
2003.06.10	WHO turns down Taiwan's application for removal from travel alert-list.
2003.06.17	WHO removes Taiwan from travel alert-list.
2003.07.05	WHO removes Taiwan from the list of SARS infected areas for no new case in 20 days.

In this step, the problem situation needs to be identified and evaluated. The root cause(s) and core problem(s) are both to be explored. Based on the purpose, the Current Reality Tree is developed according to the Table II a list of undesirable effects (UDE) related to SARS epidemic in Taiwan:

Table 2. The undesirable effects (UDE) of SARS epidemic in Taiwan

Categories	UDE Items
A. Managing issue	1. Infection area stays expanding 2. Group infection occurs in hospitals
B. Strategic issue	1. SARS virus spreads through public transportation 2. Public is panic-stricken by SARS epidemic 3. Lack of qualified hospitals for SARS patients
C. Supply chain issue	1. Medical supplies in serious shortage
D. Knowledge issue	1. Lack of knowledge about SARS virus 2. Lack of means for controlling SARS epidemic

The completed Current-Reality Tree is shown as Fig 1. From this diagram, the root causes are clearly identified as (1) Poor administration in Health Care Authority, (2) Poor management in hospitals, (3) Insufficient knowledge about virus.

In essence, the Current Reality Tree is a cause and effect diagram. We take the right-most path of "Poor management in hospital" from the Fig. 1 as example, it can be explained as following.

The "Poor management in hospital" causes the effects of "Hospitals hide SARS status" & "Hospitals incapable of handling SARS". Whereas "Hospitals hide SARS status" will further cause "Medical practitioners being loose in prevention". However, "Medical practitioners being loose in prevention" & "Lack of task hospitals" & "Infected wastes are unattended" & "Lack of qualified practitioners" together with "Shortage in medical resources" will cause "Hospital protection system fails". Furthermore, "Hospital protection system fails" will cause "Epidemic spreading from north to south" & "Group infection outbreaks" as well as "Hospitals closed in chaos". Moreover, "Epidemic spreading from north to south" & "Group infection outbreaks" & "Hospitals closed in chaos" will cause "Medical people are panic-stricken", then finally causes "SARS epidemic out of control".

Therefore, we define the task of the undertaken problem as "how to effectively control the SARS epidemic -- from the perspective of the chief public health care officer". Two sub-tasks are established as: (1) assuring the public free of the fear of the disastrous epidemic and (2) assisting and assuring hospitals in an effective execution of in-house disease control.

3.2. Step-2: Idea Finding

After defined the objectives of the problem solving project, the next following task is to develop the proposed solution through collecting a serial of solution ideas for further development. For this purpose, we deploy the TOC Future Reality Tree to establish the road map. The gap between the objective and actual is bridged with a series of intermediate tasks. The completed Future Reality Tree diagram is exploited as Fig 2. In essence, the Future Reality Tree is also a logic tree diagram describing the cause and effect relationship. The description of diagram follows the same manner as shown in the step-1.

After developing both Current Reality Tree (Fig. 1) and the Future Reality Tree (Fig.2), it is obvious that among 8 undesirable effects, seven of them can be effectively eliminated by desirable effects through the logic tree as shown in Fig. 2. The only undesirable effect left over, i.e., “insufficient knowledge about virus”, still remains as an uncontrollable constraint.

3.3. Step-3: Obstacle Finding

A serial of solution ideas generated by the Future Reality Tree is the preliminary idea. These could be a number of potential obstacles hindering under realization. In order to dig out the hidden problems, the Prerequisite Tree of TOC is deployed here to identify a prerequisite plan for examination. According to the Future Reality Tree Diagram as exploited in Fig. 2, the Prerequisite Tree Diagram for the SARS case is developed as shown in Fig. 3. A total of 15 obstacles are explored and shown as hexagons below, which block the achievement of Intermediate Objectives (IO).

3.4. Step-4: Solution Finding

After identified the intermediate objectives and obstacles, we are ready to generate the solution program. In order to achieve this purpose, two separated issues needs to be dealt with, i.e., crisis management from government perspective, in order to (1) assure the public being free of the fear of the disastrous epidemic, and (2) assist and assure hospitals in an effective execution of in-house disease control.

Therefore, the Transition Tree logic diagram is deployed based on the Prerequisite Tree diagram. Figure 4 describes the Transition Tree related the crisis management from government perspective. Packed in the darkened boxes are the proposed solution programs.

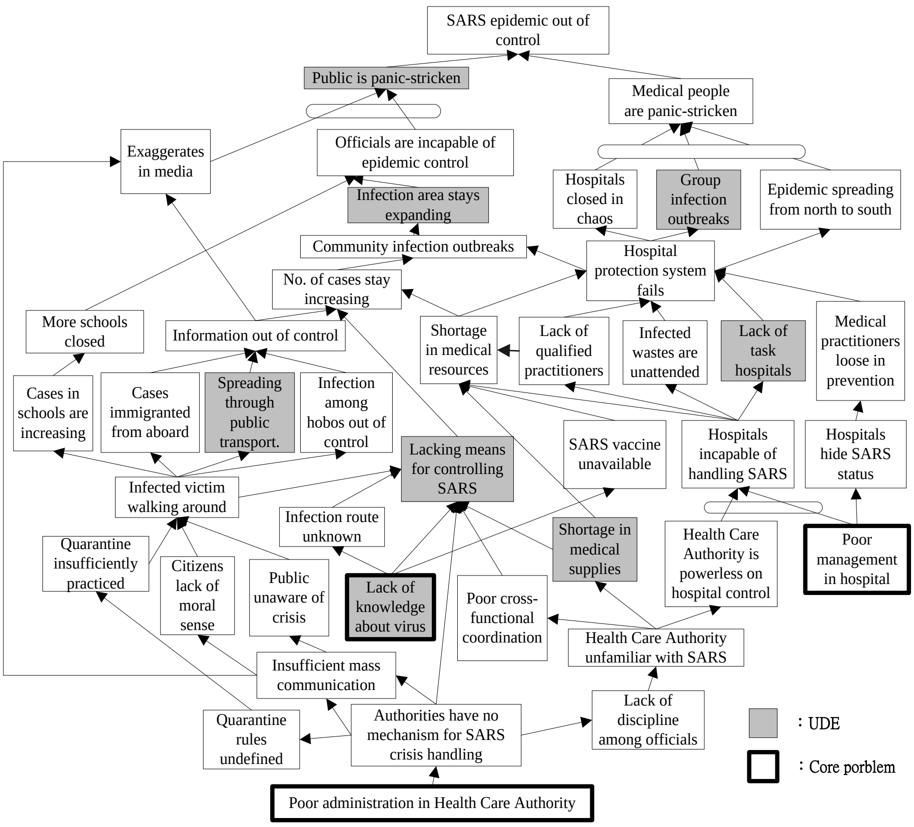

Figure 1. Current-Reality Tree for SARS Epidemic out of control

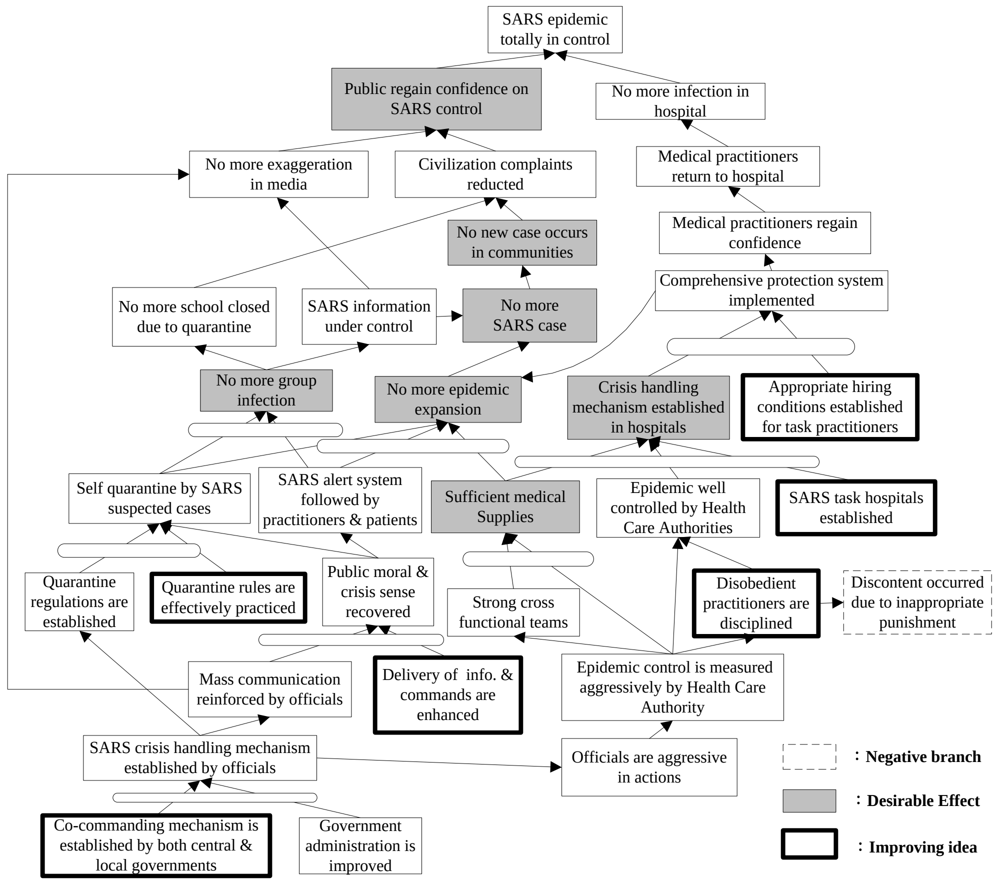

Figure 2. Future-Reality Tree aiming at SARS Epidemic under Control

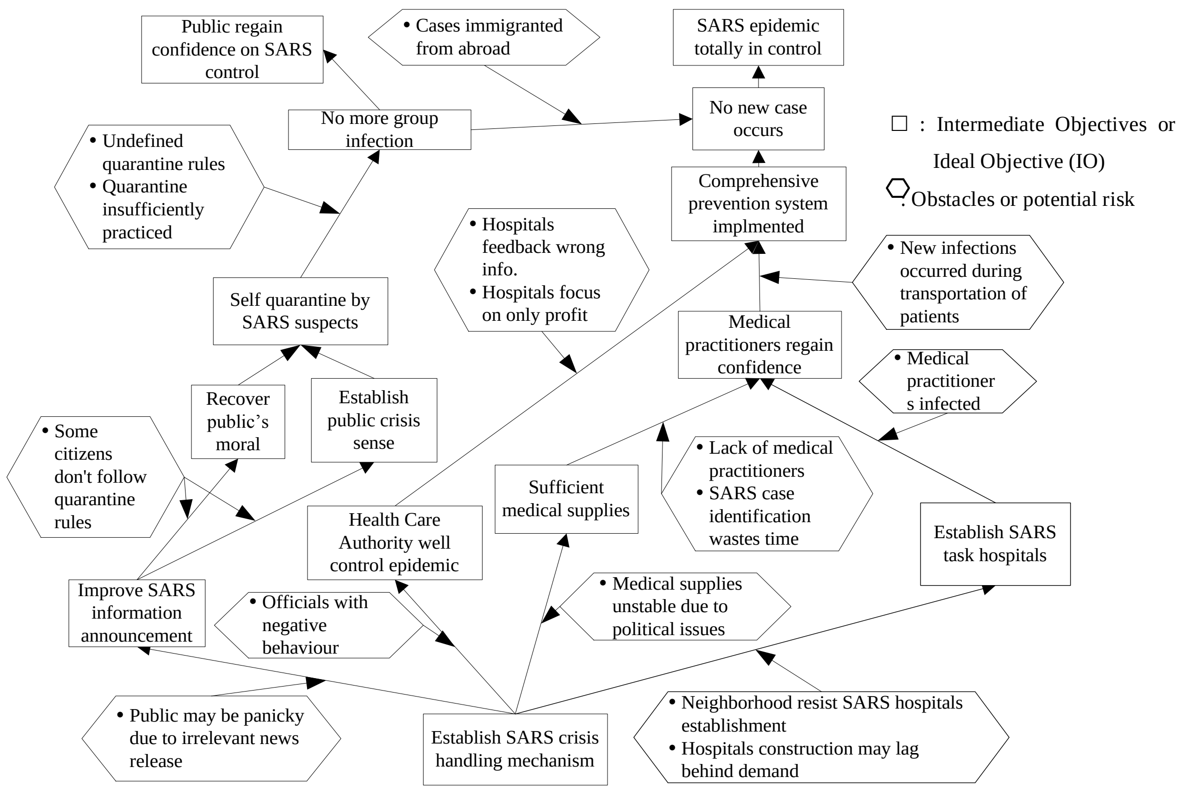

Figure 3 Prerequisites Tree aiming at SARS Epidemic under Control

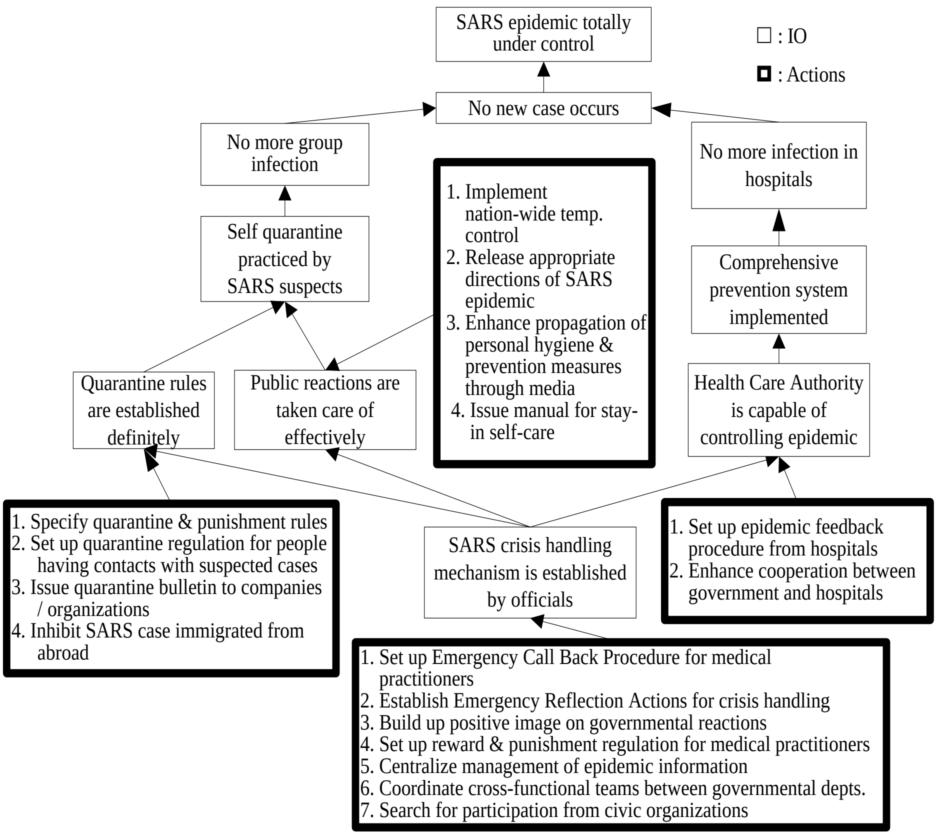

Figure 4. Transition Tree for Crisis Management from Government Perspective

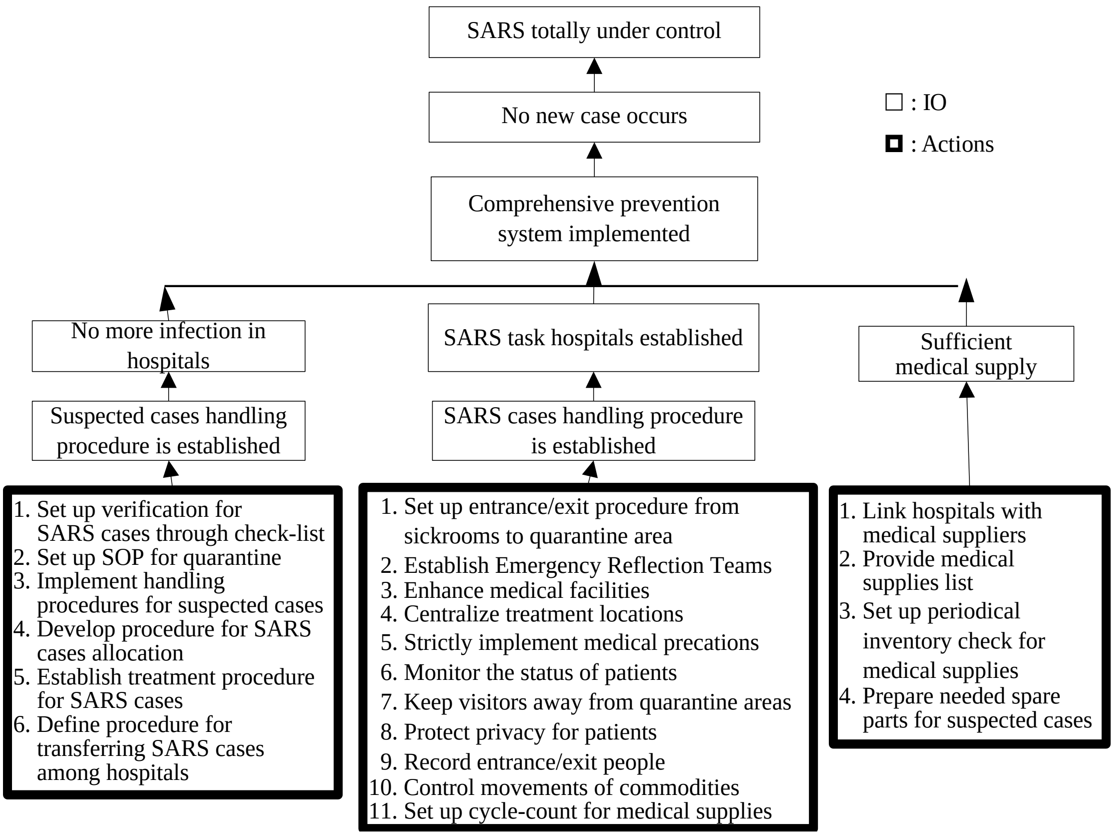

Figure 5. Transition Tree for Hospitals Supervision

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The developed solution program so proposes the following Intermediate Objectives that need to be taken in the following actions:

1) Public Reaction

(1) Implement nation-wide temperature control.
(2) Release appropriate directions of SARS epidemic.
(3) Enhance propagation of personal hygiene & prevention measures through media.
(4) Issue manual for stay-in self-care.

2) Quarantine Regulations

(5) Define quarantine regulations.
(6) Set up quarantine regulations for people having contacts with suspected cases.
(7) Issue quarantine bulletin to companies / organizations.
(8) Inhibit SARS case immigrated from abroad.

3) Controlling of SARS epidemic

(1) Set up epidemic feedback procedure from hospitals.
(2) Enhance cooperation between government and hospitals.

4) SARS Crisis Handling Mechanism

(1) Set up Emergency Call-Back Procedure for medical practitioners.
(2) Establish Emergency Reflection Actions for crisis handling.
(3) Build up positive image on governmental reactions.
(4) Set up reward & punishment regulation for medical practitioners.
(5) Centralize management of epidemic information.
(6) Coordinate cross-functional teams between governmental departments.
(7) Search for participation from civic organizations.

On the other hand, regarding to the issue of Hospitals Supervision, the Figure 5 is developed. The developed solution program proposes the following action plans to be taken:

1) Handling Procedure for Suspected Cases

(1) Set up verification for SARS cases through check-list.
(2) Set up SOP (Standard Operation Procedure) for quarantine.
(3) Implement handling procedure for suspected cases.
(4) Develop procedure for SARS cases allocation.
(5) Establish treatment procedure for SARS cases.
(6) Define procedure for transferring SARS cases among hospitals

2) SARS Cases Handling Procedure

(1) Set up entrance/exit procedure from sickrooms to quarantine area.
(2) Establish Emergency Reflection Teams.
(3) Enhance medical facilities.
(4) Centralize treatment locations.
(5) Strictly implement medical precautions.
(6) Monitor the status of patients.
(7) Keep visitors away from quarantine areas.
(8) Protect privacy for patients.
(9) Record entrance/exit people.
(10) Control movements of commodities.
(11) Set up periodical inventory check for medical supplies.

3) Medical Supplies

(1) Link hospitals with medical suppliers.
(2) Provide medical supplies list.
(3) Set up periodical inventory check for medical supplies.
(4) Prepare needed spare parts for suspected cases.

Totally, there are 21 action plans highlighted in Transition Tree for Hospitals Supervision, which can be further refined and summarized as follows:

(1) Establish and follow up SOP for SARS suspected cases and patients.
(2) Set up verification for suspected cases.
(3) Develop and practice treatment & transferring procedure for patients.
(4) Establish Emergency Reflection Teams to deal with SARS cases at centralized locations.
(5) Set up and follow up quarantine regulations for patients & visitors regarding movement control and status monitoring.
(6) Link hospitals with medical suppliers to provide sufficient medical supplies through on line cycle-count.

4. FINDING & DISCUSSIONS

In this case study, the four steps of problem solving process is deployed to solve the SARS Epidemic Control Problem. The four-step includes: (1) Problem Finding (2) Idea Finding (3) Obstacle Finding and (4) Solution Finding. As mentioned, this 4-step process is a part of the Generalized Problem Solving Process as proposed by Chang & Wang [4].

It is worth that we have successful demonstrated a tangled and complicated case such as SARS Epidemic Control can be conquered with only four logic tree diagrams, i.e. Current Reality Tree, Future Reality Tree, Prerequisite Tree & Transition Tree. There are four TOC logic trees instead of five are utilized in this case study. This is compared to traditional application where five logic trees are almost always in use [14].

Moreover, it is interesting that the four TOC logic trees fit very well with each of four problem solving steps. In other words, Current Reality Tree is used for the basic tool in the Problem Finding step; then Future Reality Tree in Idea Finding step; Prerequisite Tree in Obstacle Finding step; and Transition Tree in Solution Finding step.

As presented earlier, the SARS Epidemic Control Problem is solved by collecting undesirable effects (UDE) as the stepping stone of basis. It is further developed by deploying cause-effect-cause relationship through “if…then…” thinking process. It is revealed that a different output of UDE may lead to a different core problem, then, create a entirely different solution program. Thereby, carefully correct the critical UDE determines the future success on the identification of the core problem for further development. That is the reason why an expert is always distinguished from a novice in effectiveness of problem solving.

Based on this process of case study, it is obviously seen that the TOC problem solving follows a distinctive thinking process. The first, the negative aspects of UDEs of the problem are developed in the CRT. Secondly, the positive aspects of DEs are then deployed in FRT for finding the solution ideas. Then, further turns to the negative aspects to focus on the potential obstacles in the PT. Finally, the attention is turned to the positive aspects again by focusing on action plans for solution finding in the TT. The distinctive thinking approach helps to the problem solving in two aspects: (1) TOC provides a developing shortcut through mirror thinking process. (2) TOC enhances the clearly thinking process.

However, there are some issues opened for further research: (1) How can we ensure the appropriate core problem(s) has been explored in CRT and it is really the most meaningful one? (2) How can we process the logic trees from CRT to FRT & further from FRT to PT more effectively? (3) How can we explore key obstacles from PT and how to smoothly develop action plans from TT? (4) How to refine and summarize these feasible solution programs coming out from TT into the optimal solution scheme to be applied in the real world?

The last, it is clearly that TOC approach owns its strength including: (1) The problem solving process is easy to follow due to its obviously thinking process; and (2) The solution program has the power of getting acceptance due to its constructed presentation by deploying logic tree diagrams. Therefore, it is advisable to develop TOC in solving various problems.

5. CONCLUSION

As is mentioned often by Taiwanese health care authorities, Ebola virus disease (EVD) and SARS epidemic are both more than a medical issue, they are belong to management problem basically. As developed in this SARS case study, the TOC application is not only to fix manufacturing problems, but also deal with crisis management in public sector. This case study obviously demonstrates how a tangled and complicated problem with unprecedented crisis like a SARS case can be well analyzed and solved by the TOC problem solving process.

After completing this case study, we have successfully answered the question raised in the beginning: “What would have happened if the disease control officers owned competent problem solving skills at the first time? What if definite process was followed and appropriate actions were immediately taken in line with the development of the epidemic? The both answers in the processes are all positive.

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