Cost Effectiveness Analysis of Disaster Medicine Research Planning in Taiwan

Hon-Ping Ma, MD[1,2]; Tzong-Luen Wang, MD, PhD[1,2]

Abstract

Since 921 Chi-Chi earthquake, our country has been engaged in the research concerning disaster mitigation and response. National Science Council and other academia institutes such as Science Research Center in Department of Health have also done their best in the related works. All of the efforts have made the advances in disaster response system. However, the cost-effectiveness of the previous disaster research is still not evaluated. Because of the essential roles of disaster planning, we have to avoid the "paper plan syndrome". It is thus important to make a complete cost-effectiveness evaluation for the overall disaster scientific technique researches. We have been engaged in the related work in the past year and collected many invaluable information and data. In summary, we'd like to evaluate the impact on disaster response and cost-effectiveness of disaster research plans. The cost-effectiveness analysis is as follows. There is 25.6% mortality decrease related to the disaster compared to that of 1995-1999. For each 1% decrease in mortality, the short-term average costs are overally AFC 1.53 million NTD, AVC 8.04 million NTD; and AC 9.57 million NTD. The costs for disaster medicine planning (n=46): AFC 0.14 million NTD, AVC 0.68 million NTD; and AC 0.82 million NTD, whereas those for non-disaster medicine planning (n=46): AFC 1.39 million NTD, AVC 8.84 million NTD; and AC 1.02 million NTD. In addition, there is 9.6% decrease in properties damages related to the disaster compared to that of 1995-1999. For each 1% decrease in losses, the short-term average costs are overally AFC 4.04 million NTD, AVC 21.46 million NTD; and AC 25.55 million NTD. For disaster medicine planning (n=46), AFC is 0.38 million NTD, AVC 1.82 million NTD; and AC 2.20 million NTD. And for non-disaster medicine planning (n=46), AFC is 3.70 million NTD, AVC 2.36 million NTD; and AC 2.73 million NTD. In conclusion, the cost-effectiveness is favorable for disaster medicine research planning in Taiwan. *(Ann Disaster Med. 2005;3:91-99)*

Key words: Disaster Medicine; Evidence-Based Medicine; Cost-Effectiveness

Introduction

Since Taiwan is located in the earthquake zone and is an island country, with centralized population after urbanization, the loss on people and damage on economy will always be devastated, once a disaster occurs. The experience of 921

From Department of Medicine, Shin-Kong Wu Ho-Su Memorial Hospital, Taipei, Taiwan;[1] Graduate Institute of Injury Prevention, Taipei Medical University, Taipei, Taiwan[2]
Address for reprints: Dr. Tzong-Luen Wang, Department of Medicine, Shin-Kong Wu Ho-Su Memorial Hospital, Taipei, Taiwan
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TEL: 886-2-28389425 FAX: 886-2-28353547 E-mail: M002183@ms.skh.org.tw

earthquake is the best proof.[1-5] Since 921 Chi-Chi earthquake, our country has been engaged in the research concerning disaster mitigation and response. National Science Council and other academia institutes such as Science Research Center in Department of Health have also done their best in the related works. All of the efforts have made the advances in disaster response system.

A disaster can be created by the natural power, such as earthquake, typhoon, flooding, or by human neglect, such as fire, transportation incidence, or by human deliberately, such as terrorism and riot. A disaster may be sudden, such as earthquake, fire and airplane accidence, or gradually developed, such as drought and hunger. Some disasters can be forecasted in certain degrees, such as typhoon and flooding; but some disasters are very difficult to be forecasted, such as earthquake and tornado. Different kinds of disasters bring different impacts to human, physically and psychologically and socially. How to implement emergency rescue and first aids during a disaster to save life and reduce pain is a new subject in emergency medication. How to react in a short period of time to utilize the medical resources to the best extent and save more life is to reply on fast and accurate disaster assessment and pre-planned and well-designed system.

When an incidence causes too many victims and exceeds what the local medical facilities can afford to accommodate, it is called a disaster. At this time, any single organization or department will not be able to handle, but to integrate across other organizations and departments to gather resources and labor to manage the impact brought by the disaster. The impacts from SARS bring a serious challenge to the related technical research plan and its standard application regulation. When “a contagious disease” developed to “a vital disease disaster”, it means the disease has spread out to the extent that it has already exceeded the manageable ability of the local contagious disease defending department. During the early stage, peak time and recovery stage of SARS, this new contagious disease brings not only the medical treatment problem of a contagious disease. Because the medical industry has limited knowledge to this new disease, it raises the degree of disease defense to maintain the safety of the living environment. At the same time, it also raises the defense level form “defending a contagious disease” to “a vital disease disaster”. Taiwan has “Disaster Prevention and Response Act” for disaster prevention and response and “Communicable Disease Control Act” for contagious diseases as applicable standards. But when facing SARS, such a new and well-spread contagious disease, they seem not enough. Anyway, nothing can be done before a newly found contagious disease occurs. It also takes time to research and develop how to manage it. The experience of SARS tells us the immediate mission is to how to integrate the existing applicable systems and raise the function of our national emergency response system against disasters and vital disease disasters, before an efficient response model is established.

Last three years, it looks great from the related technical research and planning to set up of the standard application regulation in Taiwan. The main question will be that whether these research programs were cost-effective. We therein designed the following study to approach the issue.

Materials and Methods

Information collection and organization

Our method of assessment will be based on our specialists' meeting to decide the sample pollution and details of our assessment. Method of decision will be Delphi Technique. We will use anonymous questionnaires with rewards, repeat the procedures, let the specialists decide and select the important representative topics for the details of assessment, in order to obtain objective analysis and results.

The basic process includes initial research and identification of problems, decision on the need of specialists, selection of specialists, preparation of contents and details for the questionnaires, mailing, receiving and analyzing questionnaires, summarizing and providing required information to variances for second questionnaire investigation. This process is repeated until uniform opinions are reached.

Second step is to allow specialists to divide their individual responsible areas and be responsible to compare the collected information from every counties and cities in the past three years with historical information, based on collected data and the details of assessment topics, for conclusions.

Also, more than 50 percent of the county or city departments of health will be selected randomly for actual visit and interview to ensure the accuracy and reliance of information. In addition, national medical centers will be visited and interviewed according to hospital assessment teams.

For the statistical analysis and comparison on information of every topics, the standard statistical methods of SSPS and Artificial Neural Network Prediction Model will be applied.

Cost and benefit analysis

Generally, cost and benefit analysis on the operational result and quality can be done by Pareto Principle, marginal analysis, stage analysis, individual analysis and cause and effect analysis. According to the disaster medicine related research in our country, from 1996 to present, the first three methods of analysis will not be applicable due to gradually improvement on the concept of disaster medicine knowledge. Thus, individual analysis and cause and effect analysis will be applied. Individual analysis is basically to assist the management to reduce defective rate within its budget of quality control, which is convex analysis introduced by Il-Woon Kim. It is to allocate quality control budgets to each quality control process, in order to reach its maximum effectiveness.

Our national budget on disaster medical research reached its height in the next two year after the 921 earthquake. Since then, the budget is gradually reduced. Besides summarizing the results of each category in the plan and evaluating the rate of achievement on the expected results, our plan will also investigate, based on the above model, the relationship between the gradual reduction on the research budget and actual result and its rate of achievement, itemize and discuss the advantages and disadvantages.

1. Short-term Cost

TOTAL COST，TC

TC= TVC + TFC

TVC→TOTAL VARIABLE COST

TFC→TOTAL FIXED COST

AC (AVERAGE COST)

$AC = TC / Q$

AFC (AVERAGE FIXED COST)

$AFC = TFC / Q$

AVC(AVERAGE VARIABLE COST)

$AVC = TVC / Q$

$AC = TC / Q = (TVC+TFC) / Q = AVC + AFC$

MC (MARGINAL COST)

$MC = \triangle TC / \triangle Q$

$MC = \triangle TC / \triangle Q = \triangle(TFC+TVC) / \triangle Q$

$= (\triangle TFC / \triangle Q)+(\triangle TVC / \triangle Q)$

$= \triangle TVC / \triangle Q$

$\rightarrow(\triangle TFC / \triangle Q = 0)$

2. Long-term Cost

K，L may change MIN $r * k + w * L$

limited to $f(k,L) = Qo$

$Q1 \rightarrow K1$，$L1$? $W * L1 + r * K1$

$Q2 \rightarrow K2$，$L2$? $W * L2 + r * K2$

(1) LTC LONG-RUN TOTAL COST

LMC (LONG-RUN MARGINAL COST)

$LMC = \triangle LTC / \triangle Q$

LAC (LONG-RUN AVERAGE COST)

$LAC = LTC / Q$

(1)LAC is the envelope curve of SAC

EX: $K1 < K2 < K3$

$K1 \rightarrow SAC(K1)$

$K2 \rightarrow SAC(K2)$

$K3 \rightarrow SAC(K3)$

$Q1*SAC(K3) > Q2*SAC(K2) > Q3*SAC(K1)$

$= Q1*C > Q1*b > Q1*a \rightarrow$ choose K1

$Q2 \rightarrow K2 \rightarrow LAC=SAC(K2)$

$Q3 \rightarrow K3 \rightarrow LAC=SAC(K3)$

(2)$AFC=AC-AVC$ $(AC=AVC+AFC)$

(3)TP&TVC

$TP = Q = f(L，Ko) = f(L)$

$TVC = W*h = W*1/f(Q)$

(2) LMC，SMC

AT Q1，$SMC1 = LMC$

AT Q2，$ALMC = SMC2$

AT Q3，$ALMC = SMC3$

(3) LAC

(i) $Q\uparrow \rightarrow LAC\downarrow$

(ECONOMICES OF SCALE)

a. Professional Division of Work

b. Inseparable

c. Mass Purchase of Side Products

(ii) $Q\uparrow \rightarrow LAC\uparrow$ Uneconomic Size

Results

From calculation from the model mentioned in the method, average fixed cost of a disaster technical plan is NT$80,000 and average variable cost is NT$420,000. Total average cost is NT$500,000.

However, the cost of disaster technical plan varies from different types. In other words, the research plans can be categorized into two major parts, that is, disaster medicine–related plans and non-disaster medicine related plans. For disaster medicine-related plans, average fixed cost of a disaster technical plan is NT$80, 000 and average variable cost is NT$380,000. Total average cost is NT$460,000. For non-disaster medicine related plans, average fixed cost of a disaster technical plan is NT$80,000 and average variable cost is NT$510,000. Total average cost is NT$590,000.

The above data is the cost analysis of every disaster technical plan. We furthermore investigate the impact on physical insults and the cost-effectiveness of the disaster technical plans. The impact on physical insults of a disaster prevention and response plan is far different from the impact on rewards of an enterprise. For instance:

1. The physical reward of an enterprise is usually measured by properties; however, the physical reward of disaster prevention can be in term of life, reputation of an organization and other related values which are more difficult to be evaluated.
2. An enterprise has relatively shorter management cycle, more regularity and more predictable; however, a disaster has relatively longer management cycle, less regularity and less predictable.

We therein need to make the following revisions:

1. The physical rewards of a disaster prevention and response plan should be categorized as follows:
   A Property
   B Life
   C Reputation of Organization
2. The above rewards or values are passive, which means the related loss reduction as a result of successful inclusion of disaster technical plan into standard operational procedures if a similar disaster occurs.

Overall, we are comparing the loss on property and life due to the natural disasters from 2000 to 2004 and the similar size of natural disasters from 1995 to 1999, in order to obtain the curve for short-term cost analysis. If we cannot find the similar size of disaster, such as the 921 earthquake, new evolving contagious disease such as SARS and etc, these disasters will be excluded in the analysis. We will reconsider them in the long-term cost analysis.

By comparison of the loss on life due to the natural disasters from 2000 to 2004 and the similar size of natural disasters from 1995 to 1999, there is a 25.6% (367 vs. 489) reduction of loss of life from disasters. After excluding other possible causes, the short-term cost for every 1% of reduction on loss of life is calculated as follows:

1. Overall, the average fixed cost is $1,531, 000 and the average variable cost is $8, 039,000. Total cost is $9,570,000.
2. For the disaster medicine related plans, the average fixed cost is $143,800 and the average variable cost is $682,900. Total cost is $826,700.
3. For the non-disaster medicine related plans, the average fixed cost is $1,387, 000 and the average variable cost is $8, 843,000. Total cost is $10,230,000.

In a similar manner, we compare the loss on property due to the natural disasters from 2000 to 2004 and the similar size of natural disasters from 1995 to 1999 and find that the loss on property is reduced by 9.6%. After excluding other possible causes, the short-term cost for every 1% of reduction on loss of property is calculated as follows:

1. Overall, the average fixed cost is $4,041, 000 and the average variable cost is $21, 464,000. Total cost is $25,505,000.
2. For the disaster medicine related plans, the average fixed cost is $383,900 and the average variable cost is $1,823,300. Total cost is $2,207,200. Since the relation is not significant, these numbers are only for reference.
3. For the non-disaster medicine related plans, the average fixed cost is $3,703, 000 and the average variable cost is $23, 610,000. Total cost is $27,310,000.

Since the previous described disaster has longer cycle and less regularity, it is less predictable. In addition, different disasters have different cycles, different regularity and different predictability. Moreover, our country has limited disaster information in some aspects, it is still very difficult to perform long-term cost analysis.

As a result, based on the limited information, the long-term cost analysis for the disaster medicine technical plan indicates economics of scale. While the long-term cost analysis for the non-disaster medicine technical plan indicates uneconomic of scale. However, it still cannot be drawn as a good conclusion.

Discussion

This report demonstrated that disaster research plans, either disaster medicine related or non-disaster medicine related, are cost-effective in the short-term observation. The long-term impact on physical insults and property loss of these plans should be drawn as a conclusion after more large-scale investigations.

In the past 5 years, there are several problems in our disaster response systems. The experience of SARS tells us the immediate mission is to how to integrate the existing applicable systems and raise the function of our national emergency response system against disasters and vital disease disasters, before an efficient response model is established. The disaster-medicine related plans demonstrated that a well-trained professional command system is very important. Not only it will complete the missing puzzles of the professional knowledge, but also it will be discounted because the change of a commanding officer. It is also well established that Incident Command System is the accredited standard command system in all kinds of disaster nowadays, which is divided into department of execution, department of planning, department of logistics and administration, and financial department. In addition, it is essential to establish a professional disaster research organization or authority. There is no argument that the professional organization against contagious diseases is the Center of Disease Control. However, most of the disaster responses depend upon inter-department coordination. A generalized, reasonable and flexible model that can work at most conditions of disasters should be implemented under a good policy and a professional authority. All of the above conclusions are believed to have great impacts on the development of our disaster response systems, but the cost-effective analysis is rarely mentioned before. The situation may be the same in other countries. As indicated in our report, the cost-effective analysis has proven the necessity of implementing such research plans to reduce the insults of disasters in the future.

We cannot conclude if such cost effectiveness has reached maximum. There are many factors that may affect the effectiveness. For example, most of the past studies demonstrated that the disasters had unique problems that require different strategies, both quantitatively and qualitatively.[6-8] The disaster response involves variable destruction of communication system, working with different people, solving different problems, and using different resources than those for routine emergencies,[6-9] so it has to be flexible in total operation but constant in role playing. As we mentioned before, the low frequency of devastating disasters always poses a problem for hospital planners, because few planners have had enough disaster experience. Such a deficiency may be a major pitfall in designing a disaster research plan or implementing a disaster response plan. It may be the reason that so-called "paper plan syndrome" still cannot disappear as yet. One of the greatest impediments to disaster preparedness is the tendency to believe that it can be accomplished merely by the completion of a written plan. Written plans indeed are very important, but they are only one of the requirements necessary for preparedness.[10-12] A written plan can be an illusion of preparedness if the other requirements are neglected.

Second, there is still no nationally institutionalized process for data collecting, analyzing, and generalizing the education based upon past experiences. The validity of the data used in related analysis is thus questionable. Historical records of disasters beyond several decades ago were not complete and verified. Although we have utilized the data in recent 10 years, the information gathered is still limited. This is also a major limitation in our study.

Furthermore, cost-effectiveness analysis is a technique for selecting among competing wants wherever resources are limited. Developed in the military, cost-effectiveness analysis was first applied to health care in the mid-1960s and was introduced with enthusiasm to clinicians in 1977.[13] Cost-effectiveness analysis has since become a common feature in medical literature. Cost-effectiveness analysis is a tool used to aid decisions about which medical care should be offered. It is a method of comparing the cost and effectiveness of two or more alternatives. In its most common form, a new strategy is compared with current practice (the "low-cost alternative") in the calculation of the cost-effectiveness ratio: cost-effectiveness ratio=[cost $_{\text{new strategy}}$ – cost $_{\text{current practice}}$] / [effect $_{\text{new strategy}}$ – effect $_{\text{current practice}}$]. The result might be considered as the "price" of the additional outcome purchased by switching from current practice to the new strategy. And if the price is low enough, the new strategy is considered "cost-effective." However, being cost-effective does not mean that the strategy saves money, and just because a strategy saves money doesn't mean that it is cost-effective. It is also the reason why some science categories such as law and policy may not be easily evaluated by cost-effectiveness analysis.[14-20]

It's also worthwhile to recognize that cost-effectiveness analysis is only relevant to certain decisions. A cost-effectiveness analysis is relevant only if a new strategy is both more effective and more costly (or both less effective and less costly).

There are six issues that we have to mention and review critically to verify our findings to be true.[13-16] In other words, there may be some limitations if any of our data inclusion did not meet the criteria.

Comparison of the relevant strategies

Because a cost-effectiveness analysis involves marginal cost and benefits, the choice of which strategies to compare can drive the calculation and the conclusion of a cost-effectiveness analysis. Cost-effectiveness analysis is very sensitive to the choice of strategies being compared. We believe the choice being presented is really the choice that interests those engaged in disaster research.

Effectiveness of the data

It's hard to get too excited about cost-effectiveness if the effectiveness of the strategy is really unknown. So as a first step, we have to examine the information used for effectiveness.

Ideally, the data should come from randomized trials. If not, we have to scrutinize the face validity of the assumptions. We have to agree that it is still a problem in cost-effectiveness analyses in disaster researches.

Comparability of effectiveness data with the strategy used in the real world

Even if the effectiveness data are from randomized trials, it's important to ask whether they really pertain to the population and setting in which the strategy is likely to be applied. We should carefully consider the generality of the effectiveness data in this study in real conditions.

Sources of the cost data

In modeling, investigators have to make assumptions about which services are likely to be utilized differently—thus driving the difference in cost. The measurement of resource use in practice has the advantage of capturing utilization that may not be anticipated by investigators. We should look at the utilization counts themselves and have some confidence about the face validity of the cost attached to us. If more utilization doesn't equal more money, something's wrong.

Funding of the cost-effectiveness analysis

Most of the investigators believe that funding sources seem to matter. There is considerable evidence that researchers with ties to drug companies are indeed more likely to report favorable results than are researchers without such ties. Cost-effectiveness analyses are particularly susceptible to bias—intentional or not. Consequently, some journals have chosen not to publish industry-supported cost-effectiveness analyses. [21] Although our study program has been granted from Department of Health, there is no conflict of interest between Department and us.

Applicability of the analysis

Finally, readers may want to consider whether the entire exercise somehow helped them with a decision. Although some cost-effectiveness analyses have extremely high cost-effectiveness ratios and other have very low cost-effectiveness ratios, most fall somewhere in the middle. Analyses with cost-effectiveness ratios of $50, 000 per quality-adjusted life-year may conclude with an assertion that the analyzed strategy is "cost-effective."[22] It is hard to know whether or not this helps anyone make a decision.

In conclusion, our study demonstrated that the cost-effectiveness is favorable for disaster medicine research planning in Taiwan. However, many interfering factors still exist and need to be elucidated by a stepwise large-scale investigation.

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