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# Lightning mass casualty incident with a successful Triage Classification Competence of Emergency Medical Technicians under Taiwan's Fire Departments

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**Abstract:** When a disaster causes mass casualties, emergency medical technicians (EMTs) of the fire department shall rush to the disaster scene in the first instance, and shall effectively implement triage classification for large number of injured victims, so that the majority of injured victims can receive better pre-hospital medical care. The most important job of emergency medical service (EMS) at the disaster scene with mass casualties is to perform emergency triage classification, but the disparity in EMT triage classification often becomes a hot issue that we care about. In this research paper, through literature review and case study at home and abroad, and review of the status of triage classification system at present, we sorted out more important factors that would affect EMT triage classification competence, namely, individual traits of EMT, EMT rescue ability, and decision-making process. Empirical studies and survey questionnaires were taken, and the data obtained were analyzed using regression analysis, path analysis and other statistical methods. In the process, we picked out four major factors, which include "rescue skills," "vital signs," "medical care related license," and "lapse time since last rescue training." These were used in an interpretation model we constructed to help explain and identify the factors that would influence triage classification competence. It is recommended that the fire department shall continue to hold EMT trainings of all levels. These trainings shall incorporate the development of EMT decision-making ability and vital signs assessment skills. At regular intervals, emergency services technical skill appraisals and exercises simulating disaster with mass casualty shall be held, so as to strengthen EMT rescue skills. Their performance could be used for consideration of extension or renewal of their rescue license status. Training expenses and equipment purchase shall be increased. Site commander at the disaster scene is to select the triage personnel of professional rescue units with first priority placed on EMT P. The fire department shall also maintain good coordination with medical units and support groups, and good communication channels in order to receive their opinions and inputs for the implementation of their triage classification system.

**Keywords**: Accident with Mass Casualty, Triage Classification Competence, Emergency Medical Technician, Regression Models

## I. INTRODUCTION

Director of National Fire Agency Chi-Tang Yeh (1) (2010) put forward that the current challenge facing the disaster prevention and relief work in Taiwan is that the land has been devastated by major disasters such as 921 Earthquake and Typhoon Morakot. When an earthquake or a typhoon hits Taiwan, the fragile geology is prone to produce more disasters. Coupled with global climate changes in recent years, the probability and intensity of extreme precipitation have gradually become a normal cycle. Many disasters in this country have caused mass casualties. According to 2015 annual national rescue attendance records, a total of 811,914 cases were received by the fire department in the year (2). Due to widespread shortage of fire fighting manpower, firefighters often need to cover disaster relief and rescue mission at the same time. For the training of EMTs, 11,173 persons completed training in the year 2010, accounting for about 94.3% of all firefighters, in which 1,241 persons completed the basic emergency medical technician (EMT I) course; 9,467 persons completed the intermediate emergency medical technician (EMT II); and 465 persons completed the emergency medical technician-paramedic (EMT P) (3). In an attempt to increase public support and make use of civilian resources, Phoenix Rescue Volunteers are widely recruited, and given the emergency medical rescue training. By the end of 2010, about 3,823 persons had assisted the emergency medical service (EMS). The organization of Taiwan's disaster medical rescue services is divided into the fire department, health agencies, Emergency Operations Centers (EOC), emergency service hospitals, military medical units, and other volunteer organizations. Currently, the medical service units mainly responsible for disaster rescue at the scene of mass casualties are the

fire department and health agencies. The fire department dispatches front-line response rescue workers to the disaster scene in the first instance. When the rescue ambulance that first arrives at the disaster scene usually carries two EMTs, and the first things they do at the scene are to perform emergency response procedures and to request for more support. This is an important step that activates the contingency operation of disaster prevention and medical rescue system. EMTs at the disaster scene have to implement emergency triage classification for all injured victims. Triage classification can prevent large number of patients from overcrowding hospitals near the disaster area at the same time. Such phenomenon could swarm the emergency services of the area hospitals, paralyzing their emergency services. Health agencies are the most important unit in our government responsible for the entire emergency medical service system. In the central government, Department of Health under the Executive Yuan is responsible for the whole operation. In local districts, county and city health bureaus, disaster response centers, and district health agencies are responsible for the health and medical services. This country has created six emergency operation centers (EOC), and they are divided into three-level operation mechanism, respectively in charge of regional medical resources, providing correct medical information in a short time, and strengthening the regional disaster coordination for the emergency medical response functions. In the area of EMS, the emergency rescue responsibility hospitals are to provide emergency disaster medical care consultation, emergency medical personnel and equipment, drugs supply and transportation vehicles to transport patients out of the accident scene, and provide the first aid care to injured victims. The military medical units are to assist with medical air evacuation and logistical support scheduling. The military medical units are to assist regional health agencies in consolidating the resources of public and private medical institutions, and coordinating the command and control of a combat zone commander. In the event of actual disaster, military paramedics are sent into the disaster area along with relief troops to help provide victims with needed medical services.

In Taiwan, every time when a major disaster happens, the condition of initial medical rescue handling is rather chaotic. Medical rescue personnel are overwhelmed when they are suddenly faced with large numbers of injured victims (5), so they often hastily rush the victims to the hospital. William L. et al. (4) proposed that over-triage rate is positively correlated with mortality, but repeated triage can reduce errors. The main reasons and motivation behind our research are how to handle an emergency situation in a timely and proper manner in an attempt to minimize casualties, and how to avoid secondary harm in the event of a major disaster. Auf der Heide (6) pointed out that triage classification of large number of casualties in an accident is the key to effective medical care. Triage skill shall be an integral part of the emergency medical service in a major disaster. In FEMA data (7) it was mentioned that many hospitals, and all EMTs and FEMA agree that effective triage classification is necessary in the event of disaster. Chen Hui Chai et al. (8) pointed out that EMS triage classification is one of the most important works in disaster. Fu-Yuan Shih (9) proposed that when first-line EMTs of the fire department arrive at the disaster scene facing lots of injured victims, they must learn to do triage classification work effectively under high pressure, so that the majority of injured victims are able to receive the best emergency services. Tsung-ju Li (10) also pointed out that the responsibility of emergency rescue units that handle the rescue operation of mass-scale accident is not clearly defined. Further, a lack of initial stage command training, and official health service units often are not present at the scene in the first instance, leading to the fact that the fire department is in control of the scene, thus severely hampering the rescue efficiency for injured victims. Yi-kung Li et al. (11) pointed out that as the rescue situation is very urgent at the scene, EMTs have to rely on personal judgment and own rescue ability. Front-line EMTs of the fire department are currently responsible for triage classification work. From the above, it is clearly understood that when front-line EMTs perform effective triage classification at the disaster scene, they actually play an important role in screening large numbers of injured victims in a very short time. In the event of a large-scale accident, triage classification competence, almost indispensable for EMTs, is drawn from their medical care knowledge, which is worthy of further exploration.

Sheng-Chuan Hu (12) proposed several common deficiencies of EMT such as:

**1.** No triage classification work at the scene;
**2.** No liaison across different units with many victims being sent to the same hospital;
**3.** No rescue dispatch service, causing traffic chaos;
**4.** No paramedic, only trying to rush victims to the hospitals;
**5.** Even if each incident is reviewed subsequently, but the same mistakes are repeated again;
**6** Exercises cannot reflect the true situation;
**7.** No plans, so the whole rescue operation is not unified.

Although fire safety management regulations and enforcement in Taiwan are very comprehensive, there still some serious incidents since human error or negligence. I analysed the disasters in Taiwan that had caused mass casualties in the past in recent five years:

**Table 1.** Major Mass Casualty Incidents Related to Fire in Recent Years

| Name of the Incident | Date | Deceased | Wounded | Cause |
|---|---|---|---|---|
| Formosa Fun Coast Explosion | Jun. 27,2015 | 14 | 498 | Powder Explosion |
| Kaohsiung Gas Explosion | Jul. 31, 2014 | 32 | 321 | Propene Leakage |
| Beimen Hospital Fire | Oct. 23, 2012 | 13 | 59 | Arson |
| ALA Night Club Fire | Mar. 6, 2011 | 9 | 13 | Improper Lining Decoration |
| Alishan Train | March 1, 2003 | 17 | 179 | Overturn Accidents |
| | April 27, 2011 | 5 | 179 | Overturn Accidents |
| Yangmingshan National Park | June 24, 2007 | 8 | 25 | Tour Bus Rollover Accident |
| Typhoon Morakot | August 8, 2009 | 673 | 100 | Devastated LiuGuie District |

From the chart above, we could clear deduct that besides of natural disasters, human error (negligence) is the most responsible factor for these kinds of incidents, no matter the casualty is huge or minor.

These detrimental disasters raise not only the evolution but also the reexamination of rescue modes for Multiple Casualty Incident (MCI) in medical systems. I hope relevant units can learn a lesson from the following shortcomings in these disasters.

**1.** Medical care units attending and assisting the emergency rescue operation including the fire department, national health department, disaster medical and rescue emergency operations centers, emergency service hospitals, military medical units, and other volunteer organizations.

**2.** In the initial stage, the emergency rescue operation is often chaotic, as everybody is depending on EMT emergency response and experience in sending patients to hospitals.

**3.** Not in control of actual conditions at the scene, all attending units lack of cross communication and coordination for different organizations.

**4.** Triage classification station not established in the first instance, resulting in very messy operation, delaying the golden hours for rescue; or injured victims are left to go hospitals on their own without the triage classification process; overcrowding the hospital emergency rooms, so medical resources cannot be effectively allocated for all patients.

After in-depth study it is found that the above situations are closely related to the initial medical services and emergency response by EMT at the disaster scene. On the international front, major disasters with mass casualty, namely, hurricane Katrina on August 29, 2005: 1035 died; Northeast earthquake in Miyagi Prefecture Japan on March 11, 2011: 22,985 people died; Wenchuan earthquake in mainland China on May 12, 2008: 69,180 died, 17,406 missing, and 374,008 injured; Amsterdam Volendam.cafe-Bar Hotel fire in the Netherlands on January 1, 2001: a total of 241 casualties, etc. From the ways of handling the major disasters with mass casualty, and the situations in triage classification, it can be found that even though each country has a contingency plan and event handling requirements, but these precautionary steps still cannot avoid confusion from happening, so the emergency response mechanism must be carefully reviewed, as the life of injured victims are very much dependent on the emergency rescue operation.

Yung-Nien Hsu (13) pointed out that the quick and correct judgment and handling of EMT can reduce the chance of disability and mortality among injured victims. After an investigation of Taiwan's EMT training course requirements, it is found their training includes: 40 hours of EMT I, curriculum-based basic first aid, and basic rescue skills. EMT-II is the main body of our EMT training (about 85%). The training takes up 280 hours. It is divided into eight benchmark modules, where triage classification in the event of disaster with mass casualty is treated as separate chapter, including 2-hour lesson, and 4 hours field simulation exercises to introduce the basic principles of triage classification, and START triage classification method. EMT P is the

most advanced level in all training courses, teaching advanced cardiac resuscitation and life support, emergency handling of physical injuries, and other high-level technical knowledge on the rescue operations, coupled with in-depth training on how to handle triage classification in the event of disaster with mass casualty, a total of 16 hours training. EMT P may assist the emergency service director in conducting the field rescue work. According to the definition set by the Department of Health under the Executive Yuan, "emergency medical care for large numbers of injured victims" is to mean a single accident or disaster that causes fifteen or more injured victims in the incident; or else, disaster that is expected to happen which will cause more than fifteen injured victims. This research paper is focused mainly on disasters that require EMT medical care, while excluding the decontamination procedures. Related disasters include typhoons, floods, earthquakes, fires, land-based traffic accidents and other disasters, which may cause large numbers of injured victims that need emergency medical aid. Exploring the past literature, it is found that studies about EMT triage classification competence are lacking. Triage classification work is an important step to activate the medical service system in the event of disaster with mass casualty. However, this research made use of literature review and analysis to identify the important factors that would affect triage classification competence of fire department EMTs when handling disaster with large numbers of injured victims, so we selected EMTs belonging to the fire department with the most administrative resources for our field survey. We used SPSS statistical software and statistical methods to select the important factors, and we made recommendations for future EMT training and handling of disaster rescue with lots of injured victims, in the hope that triage classification competence of EMT will be further improved to protect our lives and public safety.

## II. LITERATURE REVIEW

Triage classification means to classify and determine the order of patients to receive medical care depending on the severity of their conditions among large numbers of disaster-stricken patients, or provide medical service or arrange referral on priority basis in order to increase the appropriateness of medical treatment or transfer speed (14). WT Lin et al. (15) pointed out that a triage classification system has been proposed and implemented in the United States since 1960s. Lin Chi-Hau (16) pointed out that a triage classification process can be divided into three steps: initial triage, secondary triage, third stage triage. The triage classification process can only be stopped when no more patients are waiting for medical service or hospital transfer, or patients are already dead (17). Triage classification is a commonly accepted concept all over the world, but the methods and approaches used in triage classification have yet to be unified. It is generally divided into seven types: START triage classification method, CareFlight triage classification method, CESIRA triage classification method, Sako triage classification method, SALT triage classification method, SAVE triage classification method, and B.A.S.I.C. triage classification. START triage classification method is the world's most common triage classification method. Taiwan is also adopting this triage classification method. Its assessment is primarily focused on the patient's situation: ventilation, air circulation, and awareness condition.

### 2.1 Factors influencing triage classification competence

### 2.2 Research study on decision-making theory

Decision making (36) is a process that members of an organization shall go through when they are faced with a problem or an opportunity, and they must select one out of two or more options that are present at the same time. Members need to select and execute the right choice. Hong-Lee Chang (37) pointed out that when EMT has to make decisions in limited time for under pressure, it is most likely to use intuitive decision-making model for a quick choice. Lin Zhi Ming et al. (38) pointed out that the natural ability of a person to deal with uncertainty will have a bearing on effectiveness of decision-making. Ming-Hui Chang (39) suggested that factors affecting the decision-making include personal factors and organizational factors, where the personal factors are personal values, concept, personal background, knowledge, personal intuition, habits, and personality traits; where organizational factors are organization information communication systems, interpersonal relationships within an organization, external pressure and impact on organization, and traditional practices within organization. Wen-Chin Li et al. (40) proposed that, in classic decision-making, the emphasis is often placed on the standard mode and on the control of experimental settings. From studies on naturalistic decision making, the investigation is focused on the cognitive processes, and the focus is how to use the actual experience and training of an individual to make decisions in actual circumstances. M. S. Lu (41) pointed out that ethical decision-making models include ethical mode of decision-making, utilitarian ethical decision-making model, and moralist ethical decision-making model.

Through collection and sorting of past literature, in this paper we found that factors that would affect triage classification competence are: personal qualities, EMT emergency response ability, and basic factors influencing decision-making, where the personal traits include EMT age, educational level, years of work, rescue and technical qualifications, and rescue work experience, etc.; EMT rescue ability includes rescue skills, rescue attitude, and self-decision-making ability; basic factors influencing decision-making include patient complaints, vital signs, mechanism of injury, and triage classification standards. Therefore, the above factors form the theoretical basis for this research study.

## III. RESEARCH METHODS

### 3.1 Research Framework

From the foregoing theoretical and literature review, case study, and data analysis, we sorted out relevant concepts, and introduced the triage decision-making scale (TDM I) proposed by Cone (year 2000). Also, basing on personal traits, EMT rescue capabilities, interaction between basic factors influencing decision-making and triage classification accuracy, we constructed a framework for this research study as shown in Figure 1. EMT personal traits are assumed to be independent variables that include EMT age, education level, years of work, technical qualifications rescue, and rescue experience. Rescue experience may have an impact on intervening variables and dependent variables. Intervening variables include EMT emergency response ability and basic factors influencing decision-making. Intervening variables may have a direct impact on dependent variables. We analyzed the interaction between variables, and then used independent variables to predict dependent variables. In the process, it is necessary to first understand the basic knowledge of EMT Triage classification before determining triage classification accuracy according to the situation in each case. We explored the interaction between personal traits of EMT, rescue ability, basic factors influencing decision-making, and triage classification accuracy, in an attempt to identify key factors influencing triage classification competence of the fire department EMTs.

### 3.2 Research Design

**The hypotheses used for this research are to be explained as follows:**

**Hypothesis 1 (H1):** EMT personal qualities that have significant effect on emergency response ability.

**Hypothesis 2 (H2):** EMT personal traits that have significant effect on basic factors influencing decision-making.

**Hypothesis 3 (H3**): EMT personal traits that have significantly effect on triage classification accuracy.

**Hypothesis 4 (H4):** EMT emergency response ability that has significant effect on triage classification accuracy.

**Hypothesis 5 (H5):** basic factors influencing decision-making that have significant effect on the accuracy of EMT triage.

From a draft version to the completed questionnaire, the design of the survey questionnaire had gone through six revisions. The questionnaire was developed after review of past literature with respect to the emergency medical aid capability and triage classification competence in our country and abroad. Then, we consolidated their theories to identify the factors that may affect the triage classification competence of fire department EMTs when disaster causes large numbers of injured victims. Then, we prepared the questionnaire framework taking into consideration various factors and variables. Incorporating the recommendations from many experts and scholars, we successively revised the questionnaire, and come up with a draft version of the questionnaire. We then put it through field test by selecting firefighters in the graduate school and 2-year professional program in the Central Police University as test subjects. These subjects possessed licenses of EMT II and over 8 years of practical experience. A total of 50 firefighters were selected to assist the pre-test with the draft version questionnaire. We later further revised the questionnaire to remove some unfit items to produce a corrected version of questionnaire.

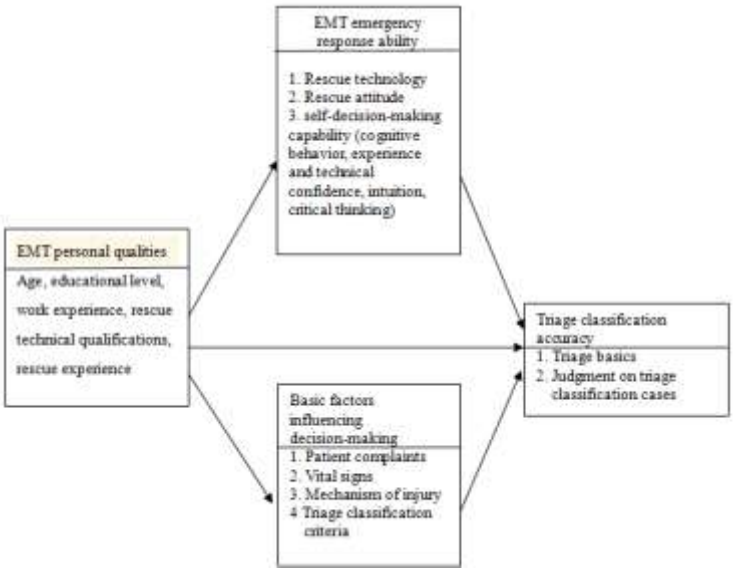


**Figure 1:** diagram of the conceptual framework

### 3.3 Samples and procedures

Since all the investigative work was conducted by first-line emergency medical rescue firefighters of city and county fire department using the survey questionnaire. We picked the fire department in four cities and counties: Taipei, Taichung, Chiayi County, and Kaohsiung City, because these districts have a high frequency of emergency rescue calls and more disasters with mass casualties. In addition, we selected 40 students from two-year professional program in the Central Police University. Their participation in the survey questionnaire enhanced the sample representation, and enabled us to gain more in-depth understanding of the triage classification competence of EMTs under the fire department. Questionnaires were sent out from February 26, 2011 to March 15, 2011. A total of 400 questionnaires were sent, and 372 returned with a recovery rate of 93%, of which 335 were valid response, and 37 were invalid response. The response rate was 88.96 %. The questionnaires data were collected and analyzed using Cronbach α, which generates a coefficient of reliability, numbers ranging from 0.787 to 0.912. The Cronbach test results were all greater than 0.5. The Kaiser-Meyer-Olkin (KMO) is a test of appropriateness, a measure of sampling adequacy, numbers ranging from 0.806 to 0.927, and the KMO test results were all greater than 0.5.

## IV. RESULTS AND DISCUSSION

### 4.1 Descriptive statistics

In this study we selected hypothesis testing for mean difference as independent samples t-test and one-way analysis of variance (ANOVA), and the significance level was $p < 0.05$ (42). However, since this research was basically an investigative research to find variables with substantial influence on each other, so we performed necessary post-hoc test (LSD method or Dunnett C method) (43). We performed an analysis on the survey results from respondents, then summarized and selected key findings as follows:

**1.** Descriptive statistics on factors influencing triage classification competence, which include the distribution of "triage classification accuracy" and the distribution of "EMT basic personal traits":

**(1)** Scoring on the "basic triage knowledge" to determine triage classification accuracy, number of samples 335, averaging 6.99 points, and standard deviation 1.832.

**(2)** Scoring on the "judgment of triage classification cases" to determine triage classification accuracy, number of samples 335, averaging 5.16 points, standard deviation 1.590.

**2. Analysis of variance for "EMT personal qualities" and "rescue ability"**

**(1)** "Service organization" has a bearing on EMT emergency response ability, as EMT emergency response services in different organizations have significantly different capabilities.

**(2)** "Number of EMTs in service units" has an effect on EMT emergency response ability, as EMT rescue ability from larger fire service units is significantly better than those in smaller units with less EMTs.

**(3)** "EMT having more experience in handling accident with mass casualties" has an effect on the emergency response rescue ability of EMT, as EMT with emergency response rescue experience perform significantly better than EMTs with no real rescue experience.

**(4)** The response rescue at the scene of disaster with mass casualty shall be implemented in accordance with standard triage classification, as the triage classification action has a bearing on EMT emergency response ability. It is believed that on each disaster scene with mass casualty EMT shall implement the standard triage classification. It is found that the rescue ability of EMT at the disaster scene with mass casualty is significantly better when EMTs follow the standard triage classification procedures, compared with EMTs without implementing the standard triage classification.

**(5)** "Highest level of firefighting related education" has an effect on EMT emergency response rescue ability. EMTs having higher firefighting education perform significantly better than those with lower firefighting qualifications.

**3. Analysis of variance for "EMT personal traits" and "basic factors influencing decision-making";**

**(1)** "EMT in fire department with fewer EMTs" has significantly more emphasis on basic factors influencing decision-making than those with more EMTs.

**(2)** "Actual implementation status of triage classification" has an effect on "basic factors influencing decision-making". It is believed that EMT implementing the standard triage classification procedures on disaster scene with mass casualty has placed significantly more emphasis on basic factors influencing decision-making, compared with those without implementing the standard triage classification.

**4. Analysis of variance for "EMT personal qualities" in relation to "triage classification accuracy";**

**(1)** "Medical care related license" has an effect on triage classification accuracy. EMTs with higher level of medical care related license attain higher triage classification accuracy. It shows that "medical care related license" and "triage classification accuracy" have a positive correlation.

**(2)** "Lapsed time since last rescue license and training" has an effect on triage classification accuracy. EMTs with shorter lapsed time since last rescue license and training produce higher triage classification accuracy.

**(3)** "Years of service" has an effect on the accuracy of triage classification. EMTs with shorter years of service perform better in the triage classification with higher accuracy than those with longer years of service.

**(4)** "Professional quality emergency response rescue personnel" has an effect on the accuracy of triage classification, as EMTs from professional quality emergency response rescue team show significantly better results than non-professional quality rescue personnel.

**5. Analysis of variance for "EMT rescue ability" and "basic factors influencing decision-making" in relation to triage classification accuracy:**

**(1)** "EMT emergency response rescue ability" has an effect on triage classification accuracy, as EMTs have poor emergency response rescue ability show significantly higher difference in the triage classification accuracy than EMTs with excellent rescue ability.

**(2)** "Basic factors influencing decision-making" has an effect on triage classification accuracy, as EMTs with less emphasis on basic factors influencing decision-making show significantly higher difference in the triage classification accuracy than those with more emphasis on basic factors influencing decision-making.

### 4.2 Interpretation model for explaining factors that would affect triage classification competence

**4.2.1** Concept analysis over related factors influencing triage classification competence

From literature review and analysis results, this study suggested that the explanation model over factor variables that would influence the triage classification shall at least include the following three concepts: EMT personal qualities, EMT emergency response ability, and basic factors influencing decision-making. To test the validity of this viewpoint, we further explored the impact of factor variables on dependent variables.

With regard to independent variables (EMT personal traits), and intervening variables (EMT emergency rescue ability, and factors influencing decision making), there are 6 variables showing significant correlation with "triage classification accuracy." These variables are "rescue skill," "vital signs," "mechanism of injury," "paramedic related license," "lapsed time sine last rescue training," and "professional quality rescue personnel." From the correlation map shown in Table 2, it can be seen that variables such as "rescue skills," "vital signs," "mechanism of injury," "medical care related license," and "professional quality rescue personnel" all show positive correlation and only variable "lapsed time since last rescue training" shows correlation. When the score of "rescue skills" is higher, it means that EMT possesses better theoretical rescue knowledge, so that EMT can

properly assess the patient and provide timely rescue. In other words, EMT can perform triage classification work according to patient's condition, so the score on "triage classification accuracy" is also higher. When the score of "vital signs" is higher, it indicates that patient's vital signs are given more significance among basic factors influencing decision making, it means that EMT has better understanding in assessment of vital signs and time element. Therefore, its influence over "triage classification accuracy" is also higher. When the score of "mechanism of injury" is higher, it means that EMT thinks that the mechanism of injury of patient is relatively important among basic factors influencing decision-making. In other words, EMT thinks that mechanism of injury of patient is one of the important works of emergency rescue technician, so it must be included in the triage classification duty transfer list. If patients are not asked about their mechanism of injury, it may result in secondary damage to the patients. Also, it may even have an impact on the diagnosis of doctors in the course of medical treatment. Therefore, its effect on "triage classification accuracy" is higher. When the score of variable "rescue license" is higher, it means that EMT possesses higher level medical care related license, so "triage classification accuracy" is also higher. The highest level of medical care related license is EMT P, while EMT instructor class is ranked in second place, EMT teaching assistant class is ranked in third place, and then EMT II is ranked in fourth place, and the last one is EMT I. When "professional quality rescue personnel" and "triage classification accuracy" show significant positive correlation, it means that "professional quality rescue personnel" perform their job with higher triage classification accuracy. Professional EMT emergency response personnel may be more familiar with the emergency rescue work than regular EMT. Since their training may be particularly strengthened on emergency care knowledge and capability, so their triage classification accuracy is higher than regular EMT. Finally, variable "lapsed time since last rescue training" shows negative value. It means that "lapsed time sine last rescue training" and "triage classification accuracy" show a negative correlation. In other words, if EMT has received the "highest level rescue training" and "lapsed time since last rescue training" is long ago, its triage classification accuracy becomes lower. Because, after EMT received rescue training, EMT may only have attended occasional rescue training in the detachment unit, and received refresher training on emergency care once a year, so EMT emergency care competence and knowledge will degrade over time, so "triage classification accuracy" drops down as "lapsed time since last rescue training" is stretched longer.

**Table 2:** shows the result of related concept analysis over factor variables influencing "triage classification accuracy"

| | Triage classification accuracy | Rescue skills | Rescue attitude | Decision-making capability | Patients complaint | Vital signs | Mechanism of injury | Triage classification criteria |
|---|---|---|---|---|---|---|---|---|
| Triage classification accuracy ($X_1$) | 1 | | | | | | | |
| Rescue skills($X_2$) | 0.140* | 1 | | | | | | |
| Rescue attitudes ($X_3$) | -0.030 | 0.310** | 1 | | | | | |
| Decision-making capability ($X_4$) | -0.005 | 0.472** | 0.645** | 1 | | | | |
| Patient complaint($X_5$) | 0.046 | 0.454** | 0.519** | 0.718** | 1 | | | |
| Vital signs($X_6$) | 0.162** | 0.486** | 0.447** | 0.643** | 0.690** | 1 | | |
| Mechanism of injury ($X_7$) | 0.112* | 0.510** | 0.369** | 0.512** | 0.591** | 0.690** | 1 | |
| Triage classification standard ($X_8$) | 0.090 | 0.515** | 0.427** | 0.665** | 0.681** | 0.731** | 0.700** | 1 |
| EMT gender($X_9$) | 0.051 | -0.063 | 0.002 | -0.080 | -0.104 | 0.021 | -0.045 | -0.084 |
| EMT age ($X_{10}$) | -0.040 | 0.067 | -0.053 | -0.040 | 0.008 | -0.115* | -0.056 | -0.053 |
| EMT education($X_{11}$) | 0.076 | 0.036 | 0.036 | 0.034 | -0.005 | 0.026 | 0.020 | 0.052 |
| Medical care related license ($X_{12}$) | 0.204** | 0.089 | -0.070 | 0.065 | 0.022 | 0.126* | 0.047 | 0.122* |
| Lapsed time since rescue training ($X_{13}$) | -0.140* | -0.045 | -0.094 | -0.032 | 0.023 | -0.100 | -0.113* | -0.048 |
| Years of | -0.094 | 0.021 | -0.086 | -0.028 | 0.011 | -0.1 | -0.076 | -0.039 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| service($X_{14}$) | | | | | | 19* | | |
| Service unit($X_{15}$) | 0.031 | 0.061 | 0.178** | 0.091 | 0.104 | 0.122* | 0.105 | 0.096 |
| Percentage of professional quality rescue personnel($X_{16}$) | 0.143** | 0.096 | -0.149** | 0.004 | -0.026 | 0.076 | -0.038 | 0.018 |
| Number of rescue technicians($X_{17}$) | -0.015 | -0.056 | 0.101 | 0.018 | -0.058 | -0.058 | -0.112* | -0.087 |
| Unit's rescue attendance rate ($X_{18}$) | 0.063 | -0.023 | -0.144** | -0.037 | -0.049 | -0.073 | -0.040 | -0.004 |
| Mass casualty rescue experience ($X_{19}$) | -0.084 | 0.043 | 0.106 | 0.114* | 0.021 | -0.066 | -0.058 | -0.027 |
| Actual status of implementation of triage ($X_{20}$) | -0.023 | 0.124* | 0.274** | 0.251** | 0.175** | 0.209** | 0.159** | 0.202** |
| Notes:<br>*. When the significance level is 0.05 (two-tailed), its correlation is significant.<br>**. When the significance level is 0.01 (two-tailed), its correlation is significant. | | | | | | | | |

***4.2.2 Review of the interpretation model over factors influencing triage classification competence***

Factor variables "rescue skills," "vital signs", "mechanism of injury," "medical care related license," and "lapsed time sine last rescue training" show significant correlation with "triage classification accuracy," in which three factor variables have positive correlation, and one factor variable has negative correlation. More specifically, "rescue skills," "vital signs", and "medical care related license" have direct positive correlation with "triage classification accuracy", and the relevancy has reached significant level, whereas "lapsed time sine last rescue training" has direct inverse correlation with "triage classification accuracy" and the relevancy has reached significant level. The concept of factor variable "rescue skills" has direct positive explanatory power in relation to "triage classification accuracy," which means when the score of "rescue skills" is high; the accuracy in triage classification is also higher. The concept of factor variable "vital signs" has direct positive explanatory power in relation to "triage classification accuracy, which means when EMT considers that patient's vital signs are important basic factors influencing decision- making, and EMT has better understanding in assessing vital signs and time element, then the results of triage classification accuracy is better. The concept of factor variable "Medical care related license" has direct positive explanatory power in relation to "triage classification accuracy, which means when the score of "medical care related license" is higher, and EMT possesses higher level of medical care related license, then the triage classification accuracy is better. The concept of factor variable "lapsed time sine last rescue training" has direct reverse explanatory power in relation to "triage classification accuracy, which means when the score of "lapsed time since last rescue training" is higher, or in other words, if the last rescue training has been a longer period of time ago, the triage classification accuracy is lower. Overall,

**"vital signs" has the greatest influence (standardized regression coefficient = 0.213). Therefore, the standardized regression equation is:**

$X_1 = 11.459 + 0.172X_2 + 0.213X_6 + 0.211X_{12} - 0.185\ X_{13}$

$X_2 = 1.188 + 0.124\ X_{20}$

$X_3 = 18.597 + 0.177X_{15} + 0.309\ X_{20}$

$X_4 = 53.551 + 0.242\ X_{20}$

$X_5 = 13.724 + 0.175X_{20}$

$X_6 = 16.369 + 0.149X_{12} + 0.129X_{15} + 0.244\ X_{20}$

$X_7 = 15.813 - 0.107X_{17} + 0.165\ X_{20}$

$X_8 = 13.182 + 0.130X_{12} + 0.206\ X_{20}$

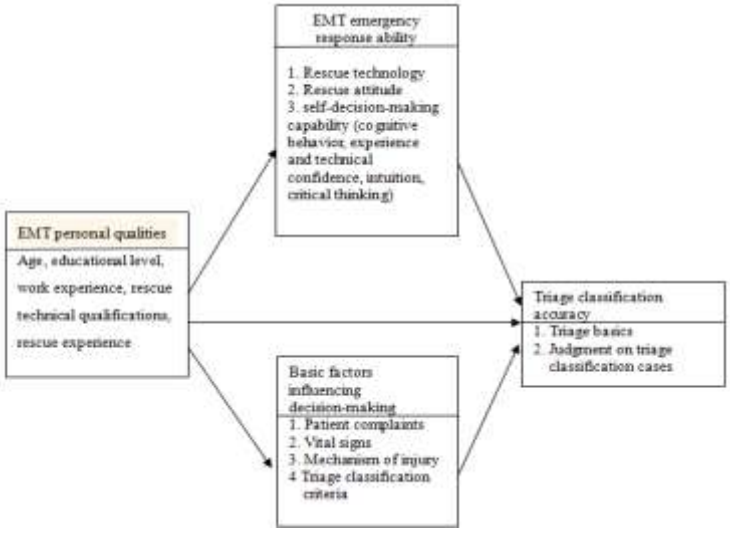


**Fig. 2.** Path analysis diagram for "Triage classification accuracy" .

The above map shows the explanatory model of "triage classification accuracy" with path diagram to show its relation with factor variables under level of significance. As it can be seen from the figure, the direct influence of "actual status of implementation of triage classification" and "triage classification accuracy" is not significant, but through "rescue skills" it can produce indirect influence on "triage classification accuracy." The direct influence of "service unit" and "actual status of implementation of triage classification" is not significant, but through "vital signs" it can produce indirect effect. "Rescue skills," "vital signs," "medical care relevant license," and "lapsed time sine last rescue training" all have direct influences on "triage classification accuracy ". More special is "medical care related license", as it not only produces indirect effect through" vital signs ", but it also has direct impact on "triage classification accuracy."

**Table 3:** regression model and determinant coefficient for triage classification accuracy

| Factor variables | Triage classification accuracy($X_1$) |
|---|---|
| Rescue skills($X_2$) | 1.350*<br>（0.121） |
| Vital signs($X_6$) | 2.421**<br>（0.213） |
| Medical care related license ($X_{12}$) | 0.932**<br>（0.193） |
| Lapsed time since last rescue training($X_{13}$) | -0.777**<br>（-0.173） |
| Professional quality rescue personnel($X_{16}$) | |
| Constant | 47.390*** |
| $R^2$ | 0.131 |
| Adjusted $R^2$ | 0.115 |
| Note 1. standardized regression coefficients are in bracket;<br>2.*p<0.05，**p<0.01，***p<0.001 | |

If we rank the factor variable influence on "triage classification accuracy" according to the level of significance, “medical care related license” is the most important influence factor, followed by “vital signs,” “lapsed time sine last rescue training,” and the last one is “rescue skills.” If we also take into account the indirect effects to analyze "triage classification accuracy," “medical care related license” is the most important influence factor, followed by “vital signs,” “lapsed time sine last rescue training,” “rescue skills,” “actual status of implementation of triage classification,” and the last one is “service unit.” Therefore, I can follow the order of importance of factor variables in trying to effectively raise "triage classification accuracy," and gain better understanding on the important factors affecting the triage classification competence of rescue technicians.

**Table 4** shows the influence of factor variables on "triage classification accuracy"

| Dependent variables | Influencing variables | Direct effect | Indirect effect | Total effect | Sequence |
|---|---|---|---|---|---|
| "Triage classification accuracy" ($X_1$)) | Rescue skills ($X_2$) | 0.172 | | 0.172 | 4 |
| | Vital signs ($X_6$) | 0.213 | | 0.213 | 2 |
| | Medical care related license ($X_{12}$) | 0.211 | 0.032 | 0.243 | 1 |
| | Lapsed time since last rescue training ($X_{13}$) | -0.185 | | -0.185 | 3 |
| | Service unit ($X_{15}$) | | 0.047 | 0.047 | 6 |
| | Actual status of implementation of triage classification ($X_{20}$) | | 0.073 | 0.073 | 5 |

## V. DISCUSSION

Basing on the above results on analysis of variance, in the paper I effectively selected factors with significant impact. According to the framework of this research, we can predict the relationship between independent variables and dependent variable, and I can explain dependent variable ("triage classification accuracy") and intervening variables ("EMT emergency response ability" and "basic factors influencing decision-making") that have the most relevance. The hypothesis test results are as follows:

- Among EMT personal qualities, variables "highest degree in firefighting education," "service unit," "number of EMT servicemen," "experience in mass casualty accident rescue," and "actual status of implementation of triage classification" all have significant effect on EMT emergency response ability. It means assumption H1 is validated.
- Variables "number of EMT in service unit" and "actual status of implementation of triage classification" have significant effect on basic factors influencing decision-making. It means assumption H2 is validated.
- Among EMT personal qualities, variables "medical care related license," "license training aid since time," "years of service," and "professional quality rescue personnel" all have significant effect on accuracy of triage classification. It means H3 assumption is validated.
- As “EMT emergency response ability” may affect the accuracy of triage classification, it indicates that EMT with poor emergency response ability would produce higher difference on triage classification accuracy, compared with those with better emergency response rescue ability. It means assumption H4 is validated.
- As basic factors influencing decision-making would affect triage classification accuracy, it indicates that EMT with less emphasis on basic factors influencing decision-making would produce significantly higher difference on triage classification accuracy, compared with those with more emphasis on basic factors influencing decision-making. It means assumption H5 is validated.

## VI. CONCLUSION

In this study, our test subjects were mainly front-line EMTs of the fire rescue department who had to rush to the scene at the first instance when disaster causes mass casualties. From actual field survey, we found the factors that would probably affect the triage classification competence of EMT in the event of disaster with mass casualty. We used statistical stepwise multiple regression and path analysis methods to test the correlation between factor variables, which may influence triage classification accuracy. We then created an interpretation model to help explain the influencing factors. Finally, we provided appropriate recommendations.

### *5.1 Theoretical contributions and practical implications*

In this study, we selected 4 factor variables from the interpretation model test: "rescue skills" from EMT emergency response rescue ability, "vital signs" from basic factors influencing decision-making, and "medical care related license" and "lapsed time sine last rescue training" from EMT personal qualities. These factor variables have significant impact over triage classification accuracy, and the regression model with determinant coefficients (R2) is 0.131. Overall, variables "rescue skills," "vital signs," and "medical care related license" have direct positive correlation with triage classification accuracy and has reached significant level. However, variable "lapsed time sine last rescue training" has direct reverse correlation with triage classification accuracy and has reached significant level. In addition, variables "service unit" and "actual status of implementation of triage classification" from EMT personal qualities have no obvious or direct significant effect on triage classification accuracy; the results have not reached significant level, but "service unit" may produce an indirect effect on triage classification accuracy going through "vital signs." "Actual status of implementation of triage classification" may produce indirect effect over triage classification accuracy going through "rescue skills" and "vital signs." Overall, "medical care related license" has maximum influence (total impact effect of 0.243), followed by "vital signs" (total impact effect of 0.213), "lapsed time sine last rescue training" (total impact effect of -0.185), "rescue skills" (total impact effect of 0.172), "actual status of implementation of triage classification" (total impact effect of 0.073), and "service unit" (total impact effect of 0.047).

### *5.2* Recommendations

Based on the above research findings, this paper has made the following recommendations to the fire department for their reference:

#### 5.2.1 Emt Training

- "Medical care related license" is the most important factor influencing triage classification competence. Triage classification competence of EMT P is better than EMT II, where EMT II is better than EMT I. Our research shows that "number of training hours" and "teaching content" have positive correlation with triage classification competence, so we have proposed that on-job training of EMT I class shall incorporate EMT II, and on-job training of EMT II class needs to incorporate EMT P. It is hoped that advanced training can enhance the disaster handling capability in the event of disaster with mass casualty. In addition, we propose that on job training of all levels for existing EMTs shall be continued, and it may be necessary for extending their emergency rescue qualification.
- Since "rescue skills" and "triage classification accuracy" show significant direct correlation, so we propose that investment in related training and equipment, rescue training integrating new technology, and assessment with sampling tests shall be continued, so as to strengthen EMT rescue skills. Also, EMTs shall regularly participate in international seminars relating to emergency medical care, and maintain liaison with hospital seminars and first-line hospitals with emergency care responsibility, in the hope of introducing theoretical knowledge and techniques to enhance EMT triage classification competence.
- Since "lapsed time from rescue license and training" and "triage classification accuracy" show significant negative correlation, it means when the lapsed time from receiving the rescue license and training is shorter, its triage classification competence is stronger. So we recommend that the rescue training and refresher training shall be held at regular intervals. The purpose is not only for EMTs to get familiar with the rescue skills, but the curriculum shall also introduce new medical knowledge whenever available. Also, it shall consider increasing the number of training hours and implement the license examination system in order to filter out those that need re-education and further training.
- Among factors influencing decision-making, "vital signs" and "triage classification accuracy" showed significant direct correlation. It indicates that, in the triage classification process, "vital signs" is an important factor influencing the decision-making. If EMT personnel have better understanding on the assessment of vital signs and time element, triage classification accuracy can be improved. So we propose

to add the decision-making capability to the EMT training curriculum, so as to strengthen the vital signs assessment.

- We found that different fire departments may produce different results in triage classification accuracy. Knowledge gained on vital signs can produce indirect impact on triage classification accuracy. Through investment in rescue training by various city and county fire service authorities, and acquisition of rescue experience by individual EMTs, different results in triage classification accuracy can be reduced or corrected. We recommend that the appraisal of the emergency response rescue skills and promotion of technical exchange between the emergency rescue units of city and county shall be continued in order to reduce regional differences.

### 5.2.2 Triage classification mechanisms

- When an accident of mass casualty happens, the first EMT team arrives at the scene is to perform initial stage triage classification. Its main tasks are to quickly classify patients and provide simple rescue on the scene. From our study, we have found that "EMT high level of medical care related license" and "emergency response rescue ability" of professional EMT personnel have significant positive correlation. We suggest that, when disaster causes mass casualty, the rescue team commander at the scene shall select EMT P from professional rescue team as first priority to do the triage classification work.
- In our study we have also found that "rescue experience with mass casualty" and "EMT emergency response rescue ability" have significant positive correlation. It indicates that EMTs with mass casualty rescue experience have better rescue ability. Since major accidents with mass casualty are so rare, it is necessary to set up simulation accidents with mass casualty for internal training at regular intervals, so as to increase EMT emergency response experience. We suggest that training and drills with simulated mass casualties shall be held regularly to allow EMTs to be familiar with the basic knowledge on triage classification and emergency response ability. Also, the fire departments shall maintain good coordination with emergency medical units, and support groups, so as to maintain good and effective interaction and communication channels.

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