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Excess mortality reduction given a "reduce patient mortality at all costs" scenario for mass burn casualties

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ABSTRACT

Objective: The aim of this study was to estimate the effect on medical resource use and mortality of full financial support from the government for treatment costs after a mass burn casualty event in Taiwan.

Methods: All patients with burn injuries from the event were included (n = 483). Each burn patient from this incident was matched to a separate burn patient identified from the National Health Insurance database. Medical care usage and mortality were compared between groups at 1-, 3-, 6-, 9-, and 12-month intervals.

Results: Regarding outpatient expenditure, burn patients from the mass casualty event had significantly higher levels of medical expenditure compared with their control counterparts at all intervals and levels of medical institution. For inpatient expenditure, patients from the mass casualty event only had higher expenditure for the first month, and excess procedures used by these patients mainly consisted of nonvital procedures such as rehabilitation training. The mortality rate was only slightly lower for this group of burn patients compared with their control counterparts.

Conclusions: Full financial support by the government in terms of medical treatment may engender only marginal additional benefits in terms of mortality if burn treatment procedures are already well established in the country.

1. Introduction

Mass casualty incidents have become relatively frequent, especially during the past few decades. International agencies, such as the World Health Organization (WHO), have developed guidelines to help countries formulate their own mass casualty management plans [1]. A mass casualty management system is complicated because many dimensions must be considered. For example, in the guidelines provided by the WHO, a response system involves preparations such as staff training, hazard analysis and risk assessment, and monitoring, surveillance, and early warning for such events. One notable component of such a system is financial and material resources [1]. A government generally must make a financial decision regarding how much resources are allocated for harm reduction. Studies have focused on the best available evidence regarding strategies for allocating scarce resources during mass casualty events [2].

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A systematic review [3] of 74 studies about mass casualty event management concluded that reducing demand for health care services is often the key to successful disaster management. However, no studies have evaluated whether complete financial support by the government to minimize casualties would lead to a substantial improvement in outcome. By using a comparison group, we analyzed the mortality reduction effectiveness of a government's full financial support to medical treatment after a mass burn casualty event.

According to the WHO guidelines, the ministry of health (MOH) of a country should conduct a cost analysis for managing mass casualty events. Moreover, if this department is experiencing funding shortages, a special budgetary allocation from the national government may be necessary [1]. A mass casualty management plan should contain provisions for both before and after disaster events. To our knowledge, no study has analyzed the effect of supplementary government medical spending after a disaster on excess mortality reduction compared with standard practices. Such an analysis is necessary because if a significant reduction in mortality can be achieved through a government's full financial support, this would justify the allocation of some of the government's budget for managing mass casualty events.

Burn care is generally considered to be expensive [4]. When medical personnel decide which medical treatments burn patients are provided, their decisions are affected by various cost considerations. Profit is often one of the considerations in treatment decisions [5]. From a patient's perspective, out-of-pocket expenditure is considered, that is, treatments that are not covered by insurance. Under normal circumstances, it is not financially feasible to provide each patient with the most advanced or costly treatment to treat their condition [6]. Studies have conducted cost analyses for burn treatments or procedures related to burns [7,8], but none have examined burn care after an unexpected mass casualty event. Under an unexpected mass casualty event, the public's objectives may be very different; for example, public emotions and political considerations may be the overriding factor in medical care expenditure rather than cost effectiveness [9]. The government thus has the option to fully cover all medical costs to achieve optimal patient outcomes. However, the effect of such medical coverage on mortality has never been examined for mass burn casualty events. Currently, studies on the costs and effects of burn patient treatment options have been conducted only at the micro level or have focused on costs of specific procedures; thus, the overall situation in terms of government burden and outcome has not been determined.

A mass burn casualty event occurred on the night of June 27, 2015. An explosion caused by the accidental combustion of a flammable cornstarch-based powder occurred at a water park in New Taipei City, Taiwan. This event led to a total of 483 people sustaining burns, with varying levels of severity. This number of burn casualties from a single unexpected disaster is among the highest of documented events [10–15]. The Taiwanese government immediately activated the emergency response system; detailed descriptions of the emergency responses that were implemented can be found in other studies [16,17].

1.1. *Taiwan's health care system*

Taiwan implemented the National Health Insurance (NHI) system in 1995, for which enrollment is compulsory for all citizens. More than 96% of the hospitals and 92% of the clinics in Taiwan are under the NHI program [18]. The majority of essential outpatient and inpatient services are covered under the NHI. In some instances, high-tech or expensive supplies must be paid out-of-pocket by the patient. After this accident, to ensure optimal patient outcomes, the government immediately removed all claims-related constraints and announced that the 483 patients were to be treated with all costs covered by the National Health Insurance Administration (NHIA) and that medical care providers would face no constraints in providing any treatment necessary to these patients. This rare situation allowed us to compare the outcomes of these patients with those of similar patients who were not granted such a removal of constraints.

2. Methods

2.1. *Study participants and the matching process*

To form a comparison group, we matched the 483 patients from the aforementioned explosion to burn patients from the NHI database based on age (a range of 10 years), sex, total body surface area (TBSA), and degree (first, second, and third) of burn. We identified 342 patients from the NHI database that were exact matches with patients from the New Taipei City incident. For the remaining patients from the explosion group without a match, we relaxed the age constraint to 30 years and removed the sex constraint (while maintaining the TBSA and burn degree constraint), and this further increased the number of matched samples by 80. For the remaining 61 patients without a match, we reset the sex and age constraint back to the original values and removed the TBSA constraint while maintaining the burn degree criteria. The remaining 61 patients were then successfully matched.

2.2. *Statistical method*

All data on medical costs are available from the NHI claims database. We linked all participants to the death registry, in which details on cause of death are available. Mortality data were extracted from the date of the burn event to 1 year after the index date. No longer duration was necessary because mortality after 1 year was unlikely due to the nature of the burn episode in question. We used descriptive statistics to compare medical costs and patient outcomes for the burn patients from the aforementioned explosion and their control counterparts. Levels of medical institution are defined as medical centers, regional hospitals, district hospitals, and clinics. Costs and outcomes were stratified into 1-, 3-, 6-, 9-, and 12-month periods according to the index date (the date of the burn event). We then analyzed medical resource utilization by the two groups according to the types of procedure employed.

2.3. Sensitivity analysis

Of the 483 patients in the control group, 57 had an unclear burn depth. However, we could not remove these 57 patients from our analysis due to the limited number of burn patients in Taiwan. To ensure our estimations were not biased due to the choice of patients for the control group, we selected two control groups, with one being the "upper-bound group" and the other been the "lower-bound group." The upper-bound group consisted of those whose burn depths were assumed to be the most severe (third degree) whenever unidentifiable from the NHI claims, whereas the lower bound group consisted of those whose burn depths were assumed to be the least severe (first and second degree), whenever unidentifiable. We report the data for the lower-bound control group in the Results section. The results of the two control groups were highly similar (data not shown).

3. Results

Table 1 presents the basic characteristics of patients from the mentioned explosion episode and their matched controls. Despite the matching process, statistical significances were still noted regarding age and sex between the two groups. Mortality rates for the two groups are presented in Table 2. The control group had slightly higher mortality rates at all intervals. Table 3 shows the average number of hospitalization days per person. The patients from the explosion episode had considerably more hospitalization days at 1-, 3-, 6-, 9-, and 12-month intervals. Regarding outpatient expenditure, patients from the water park explosion had significantly higher levels of expenditure compared with their matched control at all intervals and for all levels of medical institution. No inpatient services were available at clinics. For inpatient expenditure, burn patients from the water park explosion only had higher medical expenditure levels for the first month after the index date. After the first month, the control patients had slightly higher expenditure if they were treated at medical centers.

We further stratified the procedures prescribed to the two groups at the various time intervals. Table 4 presents the top 10 procedures utilized in outpatient and inpatient services after the event by person-time 6 months after the burn event (up to December 31, 2015). The top 10 procedures utilized were similar between the two groups, while person-time utilization was significantly higher for the mass burn incident patients. For outpatients, many of the top 10 procedures were related to exercises and rehabilitation, which are not considered intensive medical treatment.

Table 1 – Sample data.

	MCE patients		Control		p-Value
	n	%	n	%	
	483		483		
Age	22.70	4.44	24.87	7.893	<0.0001
Gender					0.0005
Male	241	49.9	290	60.04	
Female	235	48.65	178	36.85	
Unknown	7	1.45	15	3.11	
Area of burn (%)					0.0134
Area < 10	95	19.67	149	30.85	
Area 10-19	62	12.84	68	14.08	
Area 20-29	56	11.59	57	11.8	
Area 30-39	33	6.83	27	5.59	
Area 40-49	49	10.14	40	8.28	
Area 50-59	72	14.91	50	10.35	
Area 60-69	49	10.14	41	8.49	
Area 70-79	32	6.63	22	4.55	
Area 80-89	23	4.76	19	3.93	
Area > = 90	12	2.48	10	2.07	
Degree of burn					1.000
First	83	17.18	83	17.18	
Second	114	23.6	114	23.6	
Third	286	59.21	286	59.21	

MCE = mass casualty event.
TBSA = Total body surface area.

Table 2 – Mortality rate for the water park explosion patients and their matched controls (%).

Mortality rate	MCE patients	Control
Total mortality rate	3.11	3.73
1 month	2.07	2.69
3 month	2.69	3.31
6 month	3.11	3.52

MCE = mass casualty event.

Table 3 – Average hospitalization days per person and mortality rates.

	Outpatient (times) MCE patients	Control	Inpatient (days) MCE patients	Control
1 month	2.0	3.0	24.1	15.4
3 month	5.6	5.7	23.6	13.7
6 month	11.9	9.2	22.8	12.8
9 month	16.9	12.2	22.8	12.1
1 year	21.7	15.3	22.8	12.0

MCE = mass casualty event.

4. Discussions

During a mass casualty event, most governments activate their emergency response plan, and these response systems often focus on immediate surge capacities [19]. Few studies have discussed full financial medical support as part of the emergency plan. The aim of this study was to determine the benefits when a government devotes all possible resources to medical treatments after an unexpected mass burn casualty event. We revealed that excess mortality reduction was limited, whereas costs between the patients from the aforementioned explosion and the control group differed significantly. However, this does not suggest that extra expenditure was not necessary. Instead this negligible difference was most likely due to Taiwan having already achieved a high level of care for burn patients. Thus, the effect of

Table 4 – Top ten procedures utilized by outpatients and inpatients after the event by person-time (event date to December 31, 2015).

Outpatient	MCE patients n = 483		Matched control n = 483	
Procedure	Person times prescribed		Procedure	Person times prescribed
General diagnosis (medical centers or regional hospital)	4256		General diagnosis (medical centers or regional hospital)	1446
Muscle strength training	2604		Pulling movement exercise	1175
Pulling movement exercise	2440		Muscle strength training	1088
Drug dispensing fee (hospital)	2273		Drug dispensing fee (hospital)	720
Complicated items	2185		Pose training	719
Daily living training	2010		Exercise training	653
Walking training	1950		Tolerance training	621
Exercise training	1729		Mobilization	567
Limbs training	1620		Passive joint exercise	507
Palm and finger training	1578		Medium-complicated treatment	504
Inpatient				
Procedure	Person times prescribed		Procedure	Person times prescribed
Potassium	7074		Bacterial culture	340
Natrium	7009		Natrium	284
Bacterial culture	6123		Potassium	284
differential blood cell count	5549		differential blood cell count	249
Creatinine and blood supply	5491		Creatinine and blood supply	231
Blood urea nitrogen	5380		Blood urea nitrogen	220
Complete blood test	5359		Injection of a large number of liquid drops (Linger's solution, Rock solution, physiological saline, glucose solution, fruit juice or blood substitute)	217
Calcium	4835		Complete blood test	211
Chest examination	4743		Chest examination	188
Cross-matching test	4617		Calcium	186

MCE = mass casualty event.

additional expenditure by the government on medical treatment was limited, and further improvements in patient outcome were realized only at high costs. Our results should be useful for countries that also have high-quality burn care.

We found that the top 10 procedures were similar between the two groups, whereas person-time utilization was significantly higher for the mass burn incident patients. In addition, the top 10 procedures in the outpatient setting were mainly related to exercises and rehabilitation instead of intensive medical treatment. This further confirms that medical procedures for burns have already been well established in Taiwan, and additional treatments only marginally improved treatment efficacy.

Physician responses should also be considered. Prior to the disaster, to prevent the overuse and misuse of medical services, the NHIA implemented a claims-auditing system, a detailed description of which can be found elsewhere [20]. Briefly, the NHIA randomly selects approximately 7% of claims cases, and these cases are reviewed by medical professionals hired by the NHIA. If a claim is found to involve an unnecessary procedure, the provider can face up to a 100-fold reduction in reimbursement of the original claim applied. Providers thus have a strong incentive not to provide unnecessary procedures. To achieve the goal of "maximizing patient outcomes at all costs," this auditing system was also removed for the aforementioned 483 patients. Providers thus did not face any risk of claims rejections or penalties if they overused procedures. Despite this, however, it is unlikely that hospitals and physicians used this incident as an opportunity to increase reimbursement revenue. The number of burn casualties caused by the aforementioned explosion was one of the highest from a single unexpected disaster in Taiwan's history. Continuous updates on the outcomes of such patients generated considerable media attention. Consequently, hospitals competed to demonstrate superior medical treatment skills. This created a rare and notable scenario: maximizing patient outcomes was the sole objective for all providers, and providers did not face any risks (such as claims rejection) that may have threatened their revenue level.

Although the financing system may have unique characteristics that differ from those of other countries, Taiwan's case can serve as a lesson for three primary reasons. First, burn treatment procedures are well established in Taiwan, and this is not unique to Taiwan, because most developed countries also have professionals reasonably trained for treating patients with burns. Second, although Taiwan is relatively small in population and the government in Taiwan can afford to provide full financial support, according to our study, the magnitude of burn incidents, in terms of the

number of casualties, is not small. Third, although not all countries have national public health insurance, full or near-full financial support can be provided through other methods, such as donations. In this case, the primary concern should be how the money should be spent to maximize its effect and benefits to those affected by mass casualty events.

Mass casualty events are increasing in high-income countries because of terrorist attacks, and emergency care service capacities should be re-evaluated [21]. Limited resources are a common problem among nearly all countries. Austin et al. [22] noted that unnecessary transfers of burn patients incur significant costs in the United States, and this is a problem because it indicates inefficient use of a limited resource in a strained health care system. This is particularly true for mass casualty events, where a patient surge is typically involved. Therefore, the efficient use of financial resources is the key to successful recovery after mass casualty events. However, we do not argue that full medical financial support should not be used in a country with well-established burn treatment procedures. Please note that the patient outcome focused on in this study was mortality; however, burn patients experience many outcomes other than death, such as depression, alcohol abuse [23,24], and poor quality of life [25]. Therefore, providing full financial support may improve other aspects of patients and their families' lives.

We also revealed that the water park explosion patients had significantly higher outpatient expenditure compared with their matched controls at all intervals and at all levels of medical institution. However, this was not observed for inpatient expenditure after 1 month if the patients were treated at medical centers. This may have been because medical centers are equipped with relatively superior equipment and treatment protocols are relatively well established compared with other lower level medical institutions. Furthermore, because inpatient care would result in more intensive treatment compared with outpatient care, patients who required inpatient care tended to have a more severe condition; hence, no significant variations in treatment expenditure for inpatients were expected.

The limitations of this study should be considered. First, despite our efforts in the matching process, statistically significant differences still existed for age and sex between the patients from the explosion incident and control groups. This is because the number of burn patients in Taiwan was too low to allow us to perform exact matching. However, it is unlikely that the treatment procedure was significantly different due to variations in age and sex. Most differences were likely due to policy variations (such as the relaxation of the auditing system). Because of the limited number of patients with burns in the country, we could not match the facilities in the matching process. However, this may not have significantly altered our results, because the reimbursement for burn treatment by the NHI is similar across facilities within the same level of medical institution in Taiwan. Second, we could not obtain data on quality of life; the patient outcome used in this study was mortality. However, patients may have had different levels of quality of life caused by the burn incident. Third, procedures with low reimbursement from the NHI may be undercoded. In this study, we assumed that this undercoding was systematic and therefore constant between the case and control groups.

Mass casualty events normally require a high level of resource utilization. In many instances, critical care support is diverted from patients least likely to benefit, with the goal of improving population survival [26]. However, if a country already has high-quality medical care, patient outcomes may increase only marginally despite substantially higher medical resource utilization and costs. Our study revealed that patient outcomes for mass casualty events should be evaluated at a micro level rather than a macro level.

Conflict of interests

All authors have no conflict of interests.

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