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Technical Efficiency Of Post-Disaster Health Services Interventions: The 2023 Kahramanmaraş Earthquake In Turkey

Suayıp BIRINCI*

* Dr. Ministry of Health, drbirinci@gmail.com

ORCID Number: 0000-0001-8104-6198

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Abstract

Aim: In order to meet the most urgent needs of the regions affected by the biggest earthquake of the century, government, national and international actors have made enormous efforts. However, some international studies evaluating the effectiveness of previous disaster relief efforts have expressed that inefficient use of resources in the disaster relief process should be a matter of concern. The main purpose of this study is to obtain evidence to support post-earthquake healthcare interventions and to establish a reference on earthquake relief.

Methods: The data of the study covers the period from 6 February to 16 February 2023 and was obtained from the official daily reports of the Health Disaster and Coordination Centre Unit (SAKOM) of the Ministry of Health. The data consisted of allocations of rescue units, human resources, workload and other information recorded in official daily reports. In addition, Data

Corresponding author: Dr.Suayip Birinci MD, T.C. Deputy Minister of Health, e-mail:drbirinci@gmail.com

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Envelopment Analysis (DEA) method was used to evaluate the technical efficiency of health services provided in 10 provinces affected by the earthquake in the first emergency period of the Kahramanmaraş-centered earthquake.

Results: The technical efficiency scores of the health services provided in the earthquake-affected provinces are analysed, it is seen that while the average technical efficiency was 52% (SD: 0.30) on the 5th day of the earthquake, it increased significantly to 80% (SD: 0.21) on the 10th day.

Conclusion: This result shows that health services in earthquake zones have started to be provided more efficiently over time. The rapid normalisation of health services in earthquake zones is an important indicator for the performance of disaster management and crisis response teams. Despite the extensive research on earthquake response and health services individually, there's a noticeable gap in literature explicitly exploring the relationship between the two. This lacuna in research is particularly evident when it comes to examining the efficiency of health services during seismic disasters.

Keywords: Public Health, Emergency, Earthquake, Disaster, Sustainability

INTRODUCTION

Considered as one of the most destructive and deadly natural disasters in the world, earthquakes not only cause structural damage, but also have serious and long-term impacts on public health and health systems. The loss of lives of health workers or their inability to work, damage to health facilities as a result of earthquakes can render normal supply chains inaccessible and disrupt the overall functionality of the health system. This widens the gap between the growing health needs of the population and the availability of health services to meet them. Implementing effective health interventions that meet the most urgent health needs in these settings requires accurate assessment of the health status of the affected population and the functionality of the health system to respond to gaps in health services created or exacerbated by the disaster (Nickerson et al., 2015).

On 6 February 2023, Turkey experienced two main earthquakes, the first at 04.17 local time in Pazarcık district of Kahramanmaraş province with a magnitude of 7.7 and a depth of 8.6 km, and the second at 13.24 with a magnitude of 7.6 and a depth of 7 km. The natural event on 6 February 2023 is the world's largest land earthquake with a geographical area of approximately 400 km2 , including the provinces of Kahramanmaraş, Hatay, Adıyaman, Malatya, Osmaniye, Gaziantep, Kilis, Adana, Diyarbakır, Elazığ and Şanlıurfa (Figure 1). According to 2021 population statistics, 13,421,699 people live in the earthquake zone. In general, it is estimated that

9.1 million people were affected by earthquakes, 50 thousand people lost their lives and 115 thousand people were injured. Table 1 shows the data obtained from the cities affected by the earthquake. According to the data of Ministry of Health, 9881 earthquake victims, including 1834 in intensive care unit, are in inpatient treatment in hospitals in Ankara, Istanbul, Adana, Gaziantep and Antalya.

Figure 1 Earthquake Zone

Table 1. Data obtained from the cities affected by the earthquake

	Adana	Şanlıurfa	Gaziantep	Diyarbakır	Hatay	K.Maraş	Malatya	Adıyaman	Osmaniye	Kilis
PGA (g)	0,3	0,1	0,17	0,14	0,45	0,37	0,35	0,37	0,31	0,2
Affected population (n)	2.274.106	2.170.110	2.154.051	1.804.880	1.686.043	1.177.436	812.580	635.169	559.405	147.919
Affected area (km^2)	13.844	19.242	6.803	15.168	5.524	14.520	12.259	7.337	3320	1412
Affected population density ($n/km)^2$	164,3	112,8	316,6	119,0	305,2	81,1	66,3	86,6	168,5	104,8
Number of injured (5.gün)	9045	6151	13325	902	18054	9523	7433	13007	2460	853
Death toll (5.gün)	585	339	3287	300	7060	5556	869	3446	900	91
Number of injured (10.gün)	26389	902	16902	15873	2606	11444	881	16144	8699	9651
Death toll (10.gün)	7603	395	5684	3854	1117	703	92	6903	1391	346

In the first stage of the earthquake, 5527 buildings were destroyed, 145,734 buildings were severely damaged and 34,972 buildings were moderately damaged. Access to the cities was blocked due to asphalt roads being cracked. As all citizens who wanted to provide voluntary support piled up on the roads, access to the cities became much more difficult. With the collapse of buildings, many survivors set off in the opposite direction to leave the city, and on the first day of the earthquake, it became almost impossible to transport the wounded to health institutions outside the city by road. The airport in Hatay city was rendered unusable. 14 public hospitals in the region were mid-level damaged, 13 were high-level damaged, 14 of the private hospitals were mid and high level damaged and a total of 41 hospitals became unusable. Also, Hatay (56%), Kahramanmaraş (50%) and Gaziantep (50%) have most damaged public hospitals percentages. In addition, the same sequence Malatya (86%), Adıyaman (50%) and Hatay (40%) have most damaged percentages private hospitals. The table below shows the percentages of mid and high level damaged and unusable buildings percentages (Table 2). Moreover, Diyarbakır is the most highest damaged primary healthcare services percentage and Adıyaman is most damaged pharmacy rates according to the other provinces. It was not possible for the health personnel working in the usable hospitals to recover in the first days, many health personnel lost their lives in the earthquake, and the surviving health personnel had to struggle with the health or death problems of their families. Therefore, open pharmacies proportion is most critical parameters about the struggling with the effects of the earthquakes and the need for a field hospital has become inevitable for the highly damaged provinces.

Table 2. Distribution of damaged health institutions, pharmacies and field hospitals by province

	Percentage of damaged public hospitals (%)	Percentage of damaged private hospitals (%)	Damaged Primary Health Care Facility %	Percentage of Damaged Pharmacy (%)	Day 10 Proportion of Open Pharmacies (%)	Field hospitals
Adana	6	7	12.3	1	98.7	0
Adıyaman	18	50	14.4	47	36.2	4
Diyarbakır	0	0	15.8	24	97.7	0
Gaziantep	50	0	3.3	5	92.1	3
Hatay	56	40	13	36	33.3	20

K. Maraş	50	29	12.1	44	30.3	13
Kilis	0	0	3.8	0	97.9	0
Malatya	8	86	6.2	18	44.2	1
Osmaniye	14	0	1.5	4	95.2	0
Şanlıurfa	0	0	6	1	97.0	0

Response to earthquakes was coordinated through AFAD (Disaster and Emergency Management Authority). Emergency planning for the largest earthquake of the century was initiated by the ministries of Health, National Defence, Urbanisation and Environment, Internal Affairs, Energy and Natural Resources, National Education, Agriculture and Forestry, Treasury and Finance, Transport and Infrastructure, Trade, Industry and Technology, Family and Social Policies, led by AFAD. In addition to a three-month state of emergency in the 10 most affected provinces, the Government of Turkey declared a level four alert to appeal for international assistance.

AFAD, SB, MSB and OGM is the region where the 2 ships affiliated to MSB first surrounded the naval navy. Thanks to the maritime characteristics of 38 ships, in addition to 78 aircraft and 116 helicopters arriving at working airports, 52,000 patients from the region were transported to other cities in the first day of the earthquake area for all health content.

In the last 1 month, 32,335 people were assigned and 22,161 health personnel were assigned to the region through the SAKOM system, which was launched by the Ministry of Health in 2015, in order to carry out the necessary treatments and services. UMKE and ambulance teams were directed to debris rescue operations. Field hospitals were established in Hatay, Kahramanmaraş, Adıyaman and Malatya. Since it was known that the earthquake victims who were rescued from the rubble mostly needed surgical and therefore anaesthesia, then internal medicine/nephrology, gynaecology and obstetrics, urology, neurosurgery, ophthalmology, plastic and reconstructive surgery, cardiovascular surgery, paediatric surgery, thoracic surgery, intensive care, KVC intensive care and emergency medicine services, planning was made on the first day to meet the needs. In order to provide pharmaceutical support, mobile pharmacies and pharmacies that survived in the region were put on duty on the 2nd day of the earthquake. While medicines were sent to the region by the Turkish Medicines and Medical Devices Agency (TİTCK), the Social Security Institution (SGK) provided medicines and medical supplies to patients with

chronic diseases without a prescription for one time only. All other needs continued to be supplied by land, air and sea. Provinces were categorised according to the regions, the sea, the condition of the airport, the condition of the land roads and logistics were provided.

In order to meet the most urgent needs of the regions affected by the biggest earthquake of the century, government, national and international actors have made enormous efforts. However, some international studies evaluating the effectiveness of previous disaster relief efforts have expressed that inefficient use of resources in the disaster relief process should be a matter of concern (Zhang et al., 2011; Robertson et al., 2011; Liu et al., 2013; Liu et al., 2015). The main purpose of this study is to obtain evidence to support post-earthquake healthcare interventions and to establish a reference on earthquake relief.

1. RESEARCH METHODOLOGY

The data of the study covers the period from 6 February to 6 March 2023 and was obtained from the official daily reports of the Ministry of Health Health Disaster and Coordination Centre Unit (SAKOM) and the Ministry of Health. Also, This study was initiated after the necessary approvals were obtained with the decision of the Ministry of Health dated 12.05.2023 with the number E-26216721-708.99-215528364. The data consisted of allocations of rescue units, human resources, workload and other information recorded in official daily reports. The data of the emergency medical rescue system conducted by SAKOM under the leadership of AFAD were summarised and the first month of the earthquake was evaluated.

Data Envelopment Analysis (DEA) method was used to evaluate the technical efficiency of health services provided in 10 provinces affected by the earthquake in the first emergency period of the Kahramanmaraş-centered earthquake. The focus of health care efficiency analysis is the health care production of organizations, often called Economic Activity Units (UKE) or Decision Making Units (DVB), in a regional health care system (Thabrani et al., 2019). A healthcare organisation is considered technically efficient when it produces the maximum output from a given amount of input or, alternatively, when it produces a given output with a minimum amount of input. Therefore, when a health institution is technically efficient, it operates at the production frontier. DEA methods use mathematical calculations to obtain the production frontier covering all observed data. The unit of analysis used in this study is the 10 provinces affected by the

earthquake centred in Kahramanmaraş. The conceptual framework used in the study is summarised as follows based on the health services efficiency analysis model (Rogers et al., 2021):

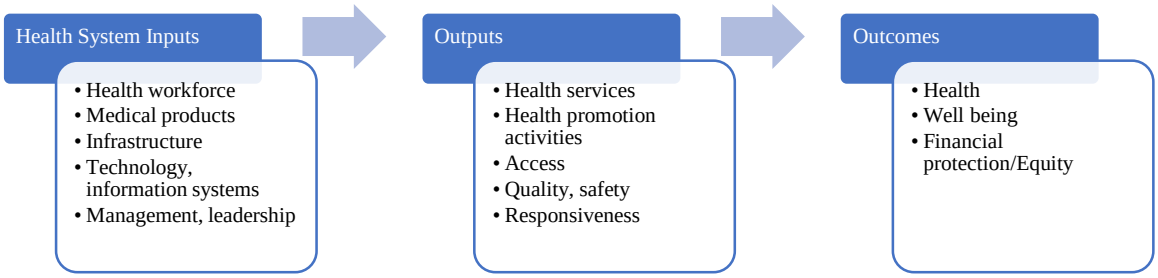

Figure 2. Health Services Efficiency Analysis Model

In previous studies on earthquake interventions, the initial emergency period was defined as the period between 24 hours and one week after the earthquake (Ardagh et al., 2012; Liu et al., 2015). In this study, the emergency period of the earthquake was defined as a total of ten days starting on the day of the earthquake (6 February) and ending on the ninth day after the earthquake (15 February), when 98.3% of all injured people were reached. Efficiency scores were also calculated for the first emergency period between 6 February and 15 February. In the study, assuming constant returns to scale, the efficiency score of each province was calculated comparatively with the province with the best efficiency.

Technical efficiency measures the ability of a decision-making unit (DMU) to produce the maximum number of programme outputs from a given number of inputs or the minimum level of inputs specified in a given number of outputs. The primary goal of health services in emergency medical rescue in an earthquake, which is primarily based on the principle of saving human life, is to save as many patients and injured people as possible as soon as possible (Liu et al., 2015). Therefore, the study has chosen the output-oriented mode.

Table 3 lists the variables used in the analysis. Input variables are the number of undamaged hospitals, the number of undamaged primary health care facilities, the number of field hospitals, the number of doctors after the earthquake, the number of newly assigned doctors and the number of UMKE personnel. The output variables are the number of injured people treated, number of operations, number of amputations and number of dialysis. DEA methods assessed the technical efficiency of each of the 10 provinces during the ten-day emergency period, based on the effects

of input on output variables. Efficiency values take a value between 0 and 1; technically efficient decision units with optimum performance have an efficiency score of 1, while inefficient decision units have an efficiency score below 1 (Thabrani et al., 2019).

Table 3. Variables used in the analysis

Input	**Output**
Number of Hospitals (undamaged %)	Total number of injured
1st level health facility (% undamaged)	Number of Operations
Number of field hospitals	Number of amputations
Number of doctors (% after earthquake)	Number of dialyses (10th day)
Number of newly appointed doctors	
UMKE Personnel	

The second analytical method used in the study is Tobit regression, which estimates (maximum likelihood estimation) the effects of the relevant variables on the efficiency of health services provided in the provinces. This approach is preferred to linear regression because DEA efficiency scores are continuous from zero to one.

Data Envelopment Analysis Programme (DEAP) 2.1 was used to evaluate the efficiency of health services with 10-day data in 10 provinces after the earthquake. Tobit regression was performed using IBM SPSS 25.0 to examine the effects of variables expected to be associated with DEAP scores. Statistical significance level was accepted as $p < 0.05$ in the analyses.

2. ANALYSIS

Personnel Management

Table 4 shows the number of doctors in 10 provinces before and after the earthquake. Graph 1 shows the number of health personnel deployed to the region in the first 5 days to provide necessary treatments and services.

Table 4. Number of Physicians

Provinces	Before the earthquake			After the earthquake			Percent change (%)
	Public	Private	Total	Public	Private	Total	
Adana	3835	759	**4594**	3160	872	**4032**	**-12**
Adıyaman	1095	45	**1140**	1053	29	**1082**	**-5**
Diyarbakır	2865	363	**3228**	2173	372	**2545**	**-21**
Gaziantep	2510	808	**3318**	2057	790	**2847**	**-14**
Hatay	2462	354	**2816**	2123	275	**2398**	**-15**
K. Maraş	1538	146	**1684**	1311	151	**1462**	**-13**
Kilis	474	5	**479**	280	5	**285**	**-41**
Malatya	1469	224	**1693**	1051	186	**1237**	**-27**
Osmaniye	759	129	**888**	582	129	**711**	**-20**
Ş. Urfa	2816	213	**3029**	2106	211	**2317**	**-24**
Total	**19823**	**3046**	**22869**	**15896**	**3020**	**18916**	**-17**

As seen in Table 4, there was a 17% decrease in the total number of doctors after the earthquake.

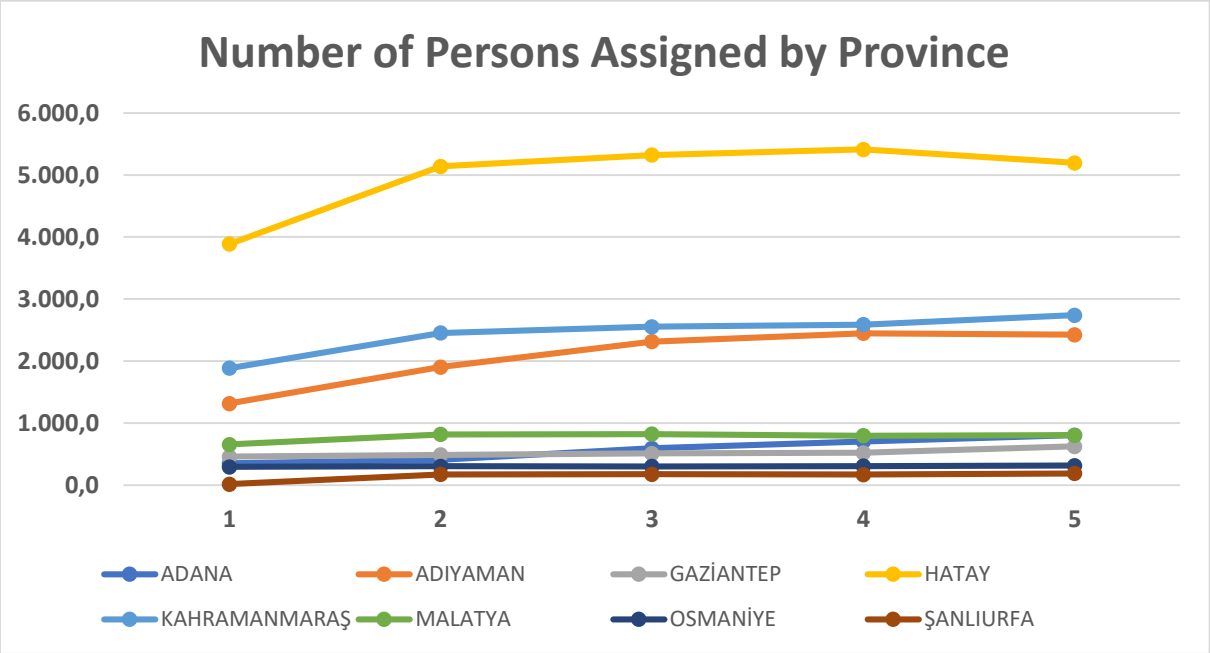

Figure 3. Number of Health Professionals Assigned to the Earthquake Region in the First 6 Days by Province

As seen in figure 3, the highest number of health personnel were assigned to Hatay, Kahramanmaraş and Adıyaman provinces after the earthquake. Table 5 shows the post-earthquake emergency health services 10th day deployment inventory.

Table 5. Emergency Health Services 10th day Assignment Inventory

		Emergency Health Vehicles		Emergency Health Personnel		Tent Units	
Provinces	**UMKE**	**Ambulance**	**UMKE**	**Ambulance**	**Emergency response unıt**	**Heavy clımate**	**Personal Shelterin g**
Kahramanmaraş	37	241	361	1040	13	3	25
Hatay	54	590	369	2391	33	3	31
Gaziantep	26	81	178	348	16	1	2
Adıyaman	74	230	547	1011	25	1	28
Osmaniye	22	36	150	162	13		6
Adana			9		3		
Diyarbakır			27		8		
Şanlıurfa			6		2		
Kilis			6		2		
Malatya	32	75	180	330	8	2	5
Air Ambulance		6					
UMKE Personnel traveling by air/land			2541				
TOPLAM	**245**	**1.259**	**4374**	**5.282**	**123**	**10**	**97**

As seen in Table 5, most emergency health personnel were assigned to Kahramanmaraş, Hatay and Adıyaman provinces after the earthquake. In the first ten days, emergency medicine, orthopaedics and traumatology and anaesthesiology and reanimation branches were the most frequently assigned.

2.1 Transfer of Injured

In the first ten days after the earthquake, 51,061 injured people were transferred to different cities by different transport options to receive necessary treatment. 95% of the injured were transferred by land, 4% by air and 1% by sea.

2.2 Health Facilities

After the earthquake, 21% of public hospitals and 17% of private hospitals were damaged. In the earthquake zone, 9.3% of 1st level health facilities were damaged (Table 2). After the earthquake, a total of 41 field hospitals were opened in Hatay, Kahramanmaraş, Adıyaman, Gaziantep and Malatya. As seen in Table 2, 14% of pharmacies were damaged in total and 72.3% of them remained open on the 10th day.

2.3 Treatment Planning

Table 6 shows the number of injured, number of amputations, number of dialysis, number of operations and number of operations performed outside the earthquake zone by provinces on the 10th day.

Table 6. Number of Injuries, Amputations, Dialysis and Surgeries by Province

	Number of injured	Amputation numbers	Dialysis numbers	Number of Surgeries	Number of operations performed outside
ADANA	26,389	59	407	335	3592
ADIYAMAN	16,144	13	3	86	1020
D.BAKIR	15,873	57	36	221	2500
G. ANTEP	16,902	75	118	311	3697
HATAY	2,606	40	62	212	2810
K. MARAŞ	11,444	33	74	159	1906
KİLİS	9,651	0	3	31	280
MALATYA	881	5	2	122	1224
OSMANİYE	8,699	2	7	61	904
ŞANLIURFA	902	51	81	235	3372
General Total	**109,491**	**335**	793	1.822	21305

As can be seen in Table 6, the injured people mostly applied to health services in Adana, Gaziantep and Adıyaman after the earthquake. The provinces with the highest number of amputations and surgeries were Gaziantep, Adana and Diyarbakır. Adana province has the highest number of dialysis patients. The provinces with the highest number of surgeries performed outside the

earthquake zone were Gaziantep, Adana and Şanlıurfa. In the first ten days, most operations were performed in the fields of gynaecology and obstetrics and orthopaedics and traumatology.

2.4 Technical Efficiency Scores

Table 7 shows the technical efficiency scores of the health services provided in the earthquake-affected provinces on the 5th and 10th day of the earthquake. While the average technical efficiency of the health services provided in the earthquake region was 52% (SD: 0.30) on the 5th day, it was calculated as 80% (SD: 0.21) on the 10th day.

Table 7. Technical Efficiency Scores by Earthquake zone

Zone	Day 5 Technical Event Scores	Day 10 technical event scores
Earthquake (10 provinces)	52%	80%

2.5 Tobit Analysis Results

The results of Tobit analysis revealed some statistically significant determinants of the technical efficiency scores of the health services provided in the earthquake zone on the 10th day (Table 8). The number of newly assigned doctors, the percentage of undamaged hospitals and the percentage of undamaged primary health care facilities were found to be statistically related with the technical efficiency scores ($p<0.05$).

Table 8. Tobit Analysis Results

Variables	**Beta**	**%95 GA**	**p**	**Adjusted R^2**	**Anova F**	**p**
Model				**%73**	**10.319**	**0.006***
Fixed	115,207	92,273-138,142	0.000*			
Number of newly appointed doctors	2,601	0.002-0.013	0.018*			
Number of hospitals (undamaged)	2,822	1,160-7,039	0.013*			
1st digit number (undamaged)	1,593	1,194-1,989	0.010*			

3. CONCLUSION AND RECOMMENDATIONS

The results and conclusions reached in this study, which was conducted to evaluate the effectiveness of health service interventions after the 6 February Kahramanmaraş earthquake, which is described as the biggest earthquake in the history of Turkey, are summarised below.

Firstly, when the technical efficiency scores of the health services provided in the earthquake-affected provinces are analysed, it is seen that while the average technical efficiency was 52% (SD: 0.30) on the 5th day of the earthquake, it increased significantly to 80% (SD: 0.21) on the 10th day. This result shows that health services in earthquake zones have started to be provided more efficiently over time. The rapid normalisation of health services in earthquake zones is an important indicator for the performance of disaster management and crisis response teams. Therefore, the increase in technical efficiency observed between days 5 and 10 indicates the ability of the teams to rapidly improve and restructure the services in the earthquake zones. The improvement trend observed in technical efficiency scores shows the flexibility and resilience of health services in the post-disaster period. This is an important lesson for disaster management and health services and this information will be utilised to better prepare for future disasters.

Second, when we look at the analysed provinces, it is observed that on the 5th day of the earthquake, Adana (100%) and Adıyaman (100%) have 100% technical efficiency scores, while the scores are at lower levels in other provinces. On the 10th day, it is observed that the technical efficiency scores in Gaziantep (100%), Şanlıurfa (89%), Diyarbakır (94%), Adana (100%) and Kilis (100%) increased significantly. This indicates that health services in these provinces were organised faster and were more effective in meeting the needs in the post-earthquake period. Analysing the reasons and practices of provinces such as Adana and Adıyaman, which had high technical efficiency scores on the 5th day of the earthquake, may provide learning opportunities to achieve similar success in other provinces. Sharing and disseminating such good practices is an important contribution to improving the efficiency of health services in earthquake zones.

On the other hand, in some provinces, especially in Hatay and Osmaniye, technical efficiency scores are still open to improvement on day 10. As a matter of fact, the damage to Iskenderun port due to the earthquake, the deterioration of the general structure of the motorways and the

unusability of Hatay airport can be shown as the most important reasons for this situation. However, with the rapidly repaired infrastructure services, the continuity of health services was ensured very intensively after the 10th day. The accessibility of health services in the first 10 days was ensured by the air, land and sea patient transfer operations, and health services were provided intensively from outside these provinces.

The tobit analysis results of the study show that newly assigned doctors, undamaged hospitals and primary health care facilities play an important role in increasing the efficiency of health services after the earthquake. These factors, which are statistically significant, are critical for increasing the efficiency of health services in earthquake zones. The fact that the number of newly assigned doctors is positively correlated with the technical efficiency scores indicates that the assignment of more doctors can increase the efficiency of health services in earthquake zones. This emphasises the importance of increasing the number of doctors for the rapid improvement of health services in the post-earthquake period. Moreover, the positive relationship between the percentage of undamaged hospitals and the percentage of undamaged primary health care facilities with the technical efficiency scores indicates that such facilities play an important role in the provision of health services. In this context, measures should be taken to increase the number and capacity of undamaged health facilities to improve the efficiency of post-earthquake health services.

The results and conclusions summarised above will be useful to improve the efficiency of health services in earthquake regions and to better understand and address the problems experienced in the post-disaster period. The technical efficiency scores varying by provinces show the geographical differences in the planning and access to health services in earthquake regions. These factors should be taken into consideration in disaster and health services management. The increase in the technical efficiency of health services shows the importance of effective communication and coordination in disaster management and health services delivery. Therefore, a well-coordinated approach at different levels and sectors should be adopted to improve the efficiency of health services in earthquake zones. To improve the effectiveness of post-earthquake health services, the importance of logistics and supply chain management should be recognised. This is particularly important for the rapid and efficient distribution of medical supplies, medicines and other health care resources. In the post-earthquake period, the importance of psychosocial support and services should not be ignored. The mental health and well-being of citizens living in earthquake zones is an important factor for the effectiveness and sustainability of general health

services. Finally, continuous monitoring and evaluation processes should be implemented to increase the effectiveness of health services in the post-earthquake period. These processes will help to measure the effectiveness and quality of services, identify areas for improvement and draw lessons to better prepare for future disasters. These conclusions can contribute to policy and strategy development processes for improving the effectiveness of post-earthquake health services and better disaster management. In addition, these results may help to identify measures to be taken to meet the needs of citizens living in earthquake zones more quickly and effectively. In this study, which was evaluated at the end of the 10th day after the 6 February 2023 earthquake, technical efficiency in health services reached 80%. As the last word, the Republic of Turkey, which has managed a major disaster unprecedented in the world throughout history, has produced strategies to be taken as an example.

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