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THE ROLE OF NONSTRUCTURAL COMPONENTS OF HOSPITALS: 1999 IZMIT EXPERIENCE

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Abstract

In September 1999, less than a month after the August 17 Izmit earthquake, 10 public hospitals from the highly damaged provinces Kocaeli, Sakarya, Yalova and Bolu of Northwestern Turkey were surveyed. Participants provided answers to a questionnaire examining the extent of damage or loss they experienced, the impact of this damage on the operation of the hospital and their assessments of the importance of different medical systems and departments to the functioning of the hospital during and following the earthquake.

This paper reports our findings that are used to identify critical nonstructural systems, essential hospital departments and the diagnostic and treatment equipments necessary to sustain functionality of a hospital or a critical care unit during or following a major seismic event. Findings reveal that, even if the structural components were intact, nonstructural failures in the facilities had remarkable effects on the functioning of hospitals following an earthquake.

Introduction

Hospitals play a key role in managing disasters. As noted by FEMA the functionality of a hospital is highly dependent on the functioning of most of its nonstructural elements (FEMA, 1989). Improved building codes and increased code enforcement have reduced the susceptibility of the hospital buildings to catastrophic failures, however, similar improvements in the performance of nonstructural systems have not been realized (Myrtle et. al., 2002) despite their high susceptibility to damage in even a fairly mild earthquake, and such damage is a major factor affecting the functionality of hospitals (Seismic Safety Commission, 1984).

As much as measuring the effects of nonstructural components, identifying the key equipment and systems that are essential to the continuing functioning of hospitals has significant implications for disaster preparedness. Nevertheless, as reported by Myrtle et.al, (2000; 2002) opinions continue to differ as to which systems or components are critical or essential in maintaining the functionality of hospitals and critical care units. This paper intends to contribute to the body of knowledge by presenting the empirical findings of a survey research conducted following a major disaster in Izmit, Turkey.

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Izmit Earthquake

Nine densely populated provinces in Northwestern Turkey (Table 1), with a total population of 12,444,619, approximately 18.3 % of Turkey's 68,000,000 people, were affected by the 7.4 magnitude earthquake on August 17, 1999. The total surface area hit by the 7.4 magnitude earthquake was 59,261 km^2, approximately 7.3 % of the Turkish lands. The August 17 earthquake, also known as the Izmit earthquake, occurred on the North Anatolian Fault (NAF) Zone with a macroseismic epicenter 40.702N, 29.987E (KOERI, 2000) near the town of Golcuk, Izmit. The province of Kocaeli, located only 12 km (KOERI, 2000) from the epicenter, had the highest damage: 8,744, approximately 57 %, of the 15,466 total deaths and 9,231, approximately 40 %, of the 23,954 of the total hospitalized injuries occurred in this province. As could be seen from Table 1, 96 % of the total deaths and 96 % of the total injuries concentrated in 4 provinces, respectively Kocaeli, Sakarya, Yalova, and Istanbul. In Sakarya, 17 % of the deaths and 22 % of the injuries; in Yalova 16% of the deaths and 19 % of the injuries; and in Istanbul 6 % of the deaths and 15 % of the injuries happened.

Izmit Earthquake's Impact on Hospitals

According to the Ministry of Health (MOH) there were 47 hospitals (Table 1) with a total of 5,060 beds in the four surveyed provinces in operation at the time of the earthquake. The hospitals ranged from 413 beds to 10 beds in size. Kocaeli, had 3 hospitals, Sakarya had 1 and Bolu had 2 hospitals with 300 or more beds. In Kocaeli, 5 hospitals had between 100-300 beds, Sakarya had 2 facilities in this size range, Bolu had 3 and Yalova had only 1 hospital with 100-bed. There were 17 major hospitals in these four provinces and the survey covered 58.8% of them.

Out of the 47 hospitals in the four provinces, 31 of them (65.9 %) were owned and operated by MOH. Their sizes ranged from 10 beds in the small cities to 400 beds in the big cities. Two of the 47 hospitals were university hospitals; 1 in Bolu with 200 beds and 1 in Kocaeli with 370 beds. Five of these 47 hospitals were owned and operated by Social Security Agency (SSA), all having 150 or more beds; 3 in Kocaeli,-- SSK Kocaeli Hospital being the biggest of these 47 hospitals with 413 beds--, 1 in Sakarya and 1 in Bolu. The survey covered 6 MOH and 3 SSA hospitals and no university hospitals were surveyed.

The only municipal owned and operated hospital was in Izmit, Kocaeli with 20 beds. Eight of the 47 hospitals, approximately 17 % of the total hospitals, were owned and operated by the private sector; 3 in Kocaeli, 4 in Sakarya and 1 in Bolu. Their bed sizes were relatively small, all less than 60 beds. The total number of beds in these private hospitals was 232, constituting only 4.5 % of the total beds. Therefore, the private sector had an insignificant share in the market. The survey covered neither private nor municipal hospitals. Also, there were no nonprofit hospitals in the region.

Table 1. Provinces Effected from the Earthquake (1999).

Province	Population	Total Dead	%	Total Injured	%	Total Number of Hospitals	Number Of Hospitals Surveyed	%	Total Number of Beds	Number of Beds Surveyed	%
Kocaeli	1,160,322	8,744	56.53	9,231	39.12	13	5	38	2,038	1,163	57
Sakarya	762,115	2,627	16.98	5,084	21.54	14	3	21	1,207	735	61
Yalova	166,382	2,501	16.17	4,472	18.95	1	1	100	100	100	100
Istanbul	8,980,425	978	6.32	3,547	15.03	138	0	0	31,350	0	0
Bolu	653,409	264	1.71	1,163	4.92	19	1	5	1,715	400	23
Bursa	1.932,000	263	1.69	333	1.41	26	0	0	3,901	0	0

Eskisehir	680,833	86	0.55	83	0.35	11	0	0	2,574	0	0
Zonguldak	655,692	3	0.01	26	0.11	8	0	0	1,705	0	0
Tekirdag	545,763	0	0	35	0.14	12	0	0	846	0	0
Surveyed Provinces	2,742,228	14,135	89.7	19,950	84.53	47	10	23	5,060	2,398	51
TOTAL	12,444,619	15,466	100	23,954	100	242	10	4	45,046	2,398	5

Source: General Directorate of Disaster Affaires of the Ministry of Public Works and Settlement and MOH statistics.

Sample and Data Collection

In September 1999, less than a month after the August 17 Izmit earthquake, 10 public hospitals from the highly damaged provinces Kocaeli, Sakarya, Yalova and Bolu of the Northwestern Turkey were surveyed. Respondents were either the facilities directors or their assistants. USC-Affiliated research associates met with the participants to explain the purpose of the research and to obtain their answers to a questionnaire examining the extent of damage or loss they experienced, the impact of this damage on the operation of the hospital and their assessments of the importance of different medical systems to the functioning of the hospital during and following the earthquake.

The research instrument utilized in this study was divided into five parts. Parts I, II, and III of the instrument examined the overall damage on the hospitals, and part IV, and V were designed to assess damage at the departmental level. Part I of the questionnaire had both open-ended and closed-ended questions about the type of problems the hospitals experienced during and after the earthquake. These questions included whether the earthquake caused problems with staffing, basic lifeline systems (water, electricity, communications, sewer disposal system, and central air supply), air conditioning, heating, piping, medical gases, as well as damage to a list of nonstructural elements. Part I also asked questions about the location, type, and extent of the damage that was experienced.

Part II of the questionnaire asked respondents the extent of earthquake related impacts on the operation of their hospitals. A 5-point Likert scale was used to measure the earthquake's impact on non-structural systems. Respondents provided answers to 42 questions about whether their hospital's ability to function was affected by availability of staff, communication systems, electrical systems as well as damage to the internal structural and nonstructural elements, and time it took to overcome these problems.

Part III of the questionnaire asked the respondents to identify the importance of different hospital units during different stages of the earthquake. These stages were: I-Immediately after the earthquake, II-During the stabilization, III-Recovery and Cleanup, and finally IV-Transition to Normal Operations. Part IV of the questionnaire was designed to assess the impact of damage on the departments and Part V of the questionnaire asked respondents to identify whether a number of mechanical and functional systems effected the operation of individual departments or units[2].

Characteristics of the Hospitals Surveyed

Six of the 10 hospitals from the provinces of Kocaeli, Sakarya, Bolu and Yalova of the region surveyed, were owned and operated by the Turkish Ministry of Health and three were hospitals operated by the Social Security Agency (SSA) of Turkey. The SSA hospitals were SSK Kocaeli Hastanesi, SSK Izmit Hastanesi and finally SSK Adapazari Hastanesi. The final hospital, Toyotasa Acil Yardim Hastanesi, was an Emergency Hospital operated by the Ministry of Health.

[2] See Myrtle et. al 2002 for the development of the survey instrument.

The 10 hospitals surveyed had a total of 2,398 beds, and covered 51.3% of the total beds in the four provinces (Table 2). These 10 hospitals employed a total of 558 doctors, of which 420 were specialists and 138 were practitioners in 1998. During the same year these 10 hospitals served to 2,541,636 patients and performed 30,462 surgical operations.

Table 2. Surveyed Hospitals Before the Earthquake (1998)

Hospital	Beds	Blood Center	Specialists	Practitioners	Out-Patients	Discharged In Patients	Deaths	Total Patient Days	Surgical Operations	Deliveries
Kocaeli Devlet Hast	400	1	63	36	343,220	17,506	427	71,152	3,637	2,745
Gölcük Devlet Hast	100		25	18	105,456	4,499	25	16,169	1,174	1,417
Karamürsel Devlet Hast	50		12	7	82,127	2,633	11	7,616	514	536
SSK Kocaeli Hast	200		38	8	277,927	14,430	132	67,893	4,808	1,832
SSK İzmit Hast	413		37	9	440,429	25,647	340	114,395	5,306	3,820
Sakarya Devlet Hast	400	1	74	13	316,411	12,594	390	57,904	2,879	
Toyotasa Acil Yrd.Hast	55		16	11	27,798	1,174	15	7,491	746	1
SSK Adapazarı Hast	280		41	10	416,556	17,149	325	75,646	5,051	3,513
Düzce Devlet Hast	400	1	61	11	231,762	15,248	183	76,241	3,857	3,614
Yalova Devlet Hast	100		53	15	181,524	7,546	56	30,384	2,490	1,931
TOTAL	2,398	3	420	138	2,423,210	118,426	1,904	524,891	30,462	19,409

Based on the MOH statistics.

Kocaeli, Sakarya and Yalova provinces were chosen because they had the highest percentage of the total deaths, total injures and total damaged buildings. Although Yalova is a very small province with only one hospital, it was included in the survey because of the massive damage in the province. Although Bolu did not suffer as much damage as Istanbul, it was included in the study sample. The largest hospital of western Bolu, Duzce Devlet Hastanesi, rather than the other hospitals in the province, was chosen due to the concentrated damage on the western half of the province. The damages in provinces Bursa, Eskisehir, Zonguldak and Tekirdag were relatively small, less than 1 % except in Bursa, and thus no hospitals from those provinces were included in the survey.

In Kocaeli province, 5 of the 13 hospitals, 38 % of the total, were surveyed. These 5 hospitals had 1,163 beds, 59 % of the total beds in the province. Three of the 5 surveyed hospitals in this province were owned and operated by MOH. Kocaeli Devlet Hastanesi was the largest of these with 400 beds and 99 physicians, and was located in Izmit, the largest city of the province. The other 2 MOH owned and operated hospitals, Golcuk Devlet Hastanesi and Karamursel Devlet Hastanesi were relatively small size hospitals however, they were the largest facilities in those cities.

The other 2 hospitals in the province were SSK Kocaeli Hastanesi and SSK Izmit Hastanesi. Both were owned and operated by SSA and were located in the city of Izmit. SSK Kocaeli Hastanesi had 200 beds and 46 physicians in 1998. SSK Izmit Hastanesi was the biggest of all 10 surveyed hospitals with 413 beds. Its medical staff of 46 physicians was among the smallest compared to the hospital's size. Even so, the hospital provided health services to 466,076 patients (1998), which represents the highest number of patients in between the 13 hospitals in the province. The only university hospital of the province, relatively large in size, was not included in the survey.

In Sakarya province, 3 of the 14 hospitals were surveyed. Two of these were general hospitals and the third, Toyatasa Acil Yardim Hastanesi, was an emergency hospital. All three were located in the city of Adapazari. These 3 hospitals had 735 beds representing 64 % of the total beds in the province. Sakarya Devlet Hastanesi, with 400 beds, and Toyotasa Acil Yardim Hastanesi, with 55 beds, were owned and operated by MOH. SSK Adapazari Hastanesi had 280 beds and supplied health services to 433,705 patients, the highest number in the province in 1998. It performed 5,051 surgical operations and 3,513 deliveries. The hospital had a total of 51 physicians, a relatively low number given the amount of the service it provided.

Overall, SSA hospitals had the highest number of patients (Table 2), and had performed the highest number of surgical operations. However, they also had proportionally the smallest number of the physicians.

Finally, in the province of Yalova, the only hospital, MOH owned and operated, was included in our survey. In 1998, Yalova Devlet Hastanesi employed 68 physicians provided health services to 7,546 inpatients and to 181,524 outpatients. They also performed 2,490 surgical operations in 1998.

In Kocaeli, Sakarya and Yalova provinces and in the city of Duzce of Bolu province, a total of 89 health facilities (Table 3) including hospitals, small size public health centers, laboratories and administrative buildings were damaged as a result of the Izmit earthquake. Twenty seven percent of those facilities were either collapsed or were heavily damaged. The remaining 72.9% were either moderately or slightly damaged. Of all the damaged health facilities 84.3% were in Kocaeli and Sakarya provinces. In these 4 provinces, earthquake damaged 24.7% (121) of the 489 pharmacies, of which 57 (47%) pharmacies were heavily damaged. Similarly heavy damage to the pharmacies was more concentrated in the Kocaeli and Sakarya provinces.

Table 3. Damage to Health Facilities

	# of Damaged Health Facilities			# of damaged Pharmacies					
Province	Heavily	Slightly	Total	Heavily	Moderately	Slightly	Total	# of Undamaged Pharmacies	# of Hospital Beds Lost
Kocaeli	9	22	31	35	20	11	66	193	1,190
Sakarya	6	46	52	13	7	7	27	157	568
Yalova	3	1	4	0	1	2	3	56	0
Bolu/ Duzce	1	1	2	9	11	5	25	83	197
Total	19	70	89	57	39	25	121	489	1,955

Source: Prime Ministry Crisis Management Center (PCMC)

The statistics show that hospitals in these 4 provinces lost 1,955 of their total beds as a result of the earthquake damage and Kocaeli (1,190) and Sakarya (568) were the two provinces with the biggest losses. Thirty-six percent of the total (1,955) bed losses in the four provinces were in the 10 surveyed hospitals. Overall the 10 hospitals lost 70.6% of their bed capacity. In 5 of the 10 hospitals, namely Kocaeli Devlet Hastanesi (92.5%), Sakarya Devlet Hastanesi (89.75%), SSK Kocaeli Hastanesi (85%), SSK Izmit Hastanesi (82.3%) and SSK Adapazari Hastanesi (71.5%), the damage was very significant. These five hospitals are located in the two cities, Izmit and Adapazari, and they were big facilities. On the other hand, 3 of the 10 hospitals did not have any bed loss despite the fact that they were as close to the epicenter of the earthquake as the other heavily damaged hospitals. One common characteristic of them were they were relatively small size hospitals.

Table 4. Number of Beds

Hospital	Before the Earthquake	After the Earthquake	Loss %
Kocaeli Devlet Hast	400	30	92.5
Gölcük Devlet Hast	100	30	70
Karamürsel Devlet Hast	50	50	0
SSK Kocaeli Hast	200	30	85
SSK İzmit Hast	413	90	82.3
Sakarya Devlet Hast	400	41	89.75
Toyotasa Acil Yrd.Hast	55	55	0
SSK Adapazarı Hast	280	80	71.5
Düzce Devlet Hast	400	200	50
Yalova Devlet Hast	100	100	0
TOTAL	2,398	706	70.6

Source: Prime Ministry Crisis Management Center (PCMC)

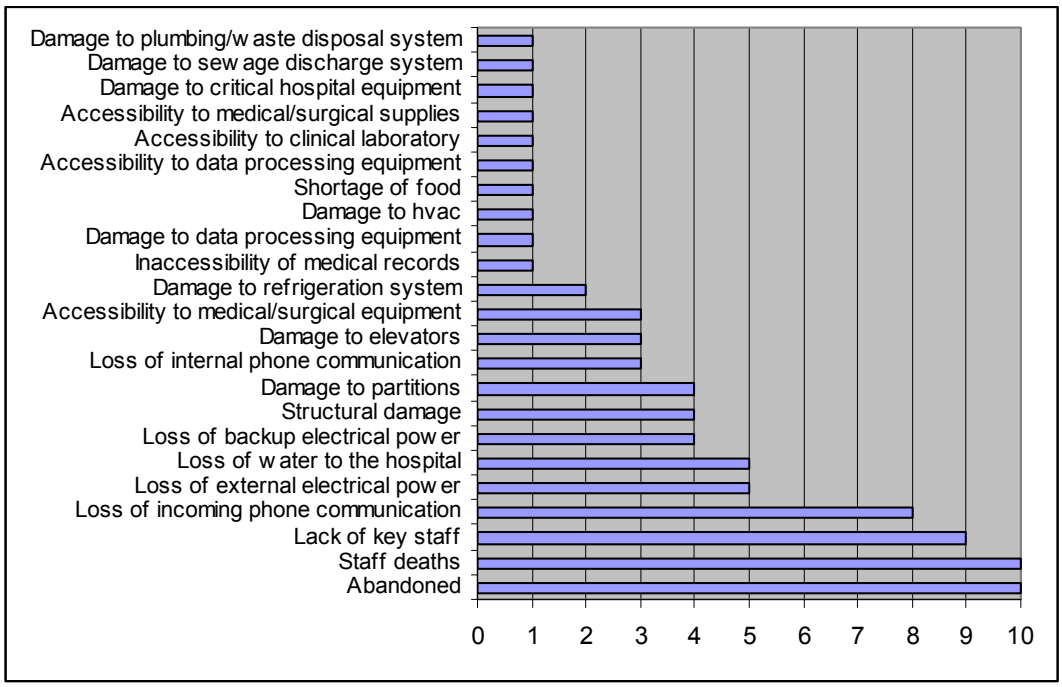
Due to the damage caused by the earthquake, all hospitals had to deliver their services either in open areas or in tents for a time period ranging between two days to two weeks. One of the main reasons for not being able to use the facilities was continuing damage by the aftershocks. After immediate treatment, all the existing and arriving patients were transferred to the other cities by ambulance, helicopter and sea bus.

Findings: Damage to the Nonstructural Components of Hospitals

All of the 10 surveyed hospitals reported they had been abandoned following the earthquake. Three of those were reoccupied within several hours and others have yet to be reoccupied. Since the interviews were conducted while most of the hospitals were operating in temporary facilities, some of the responses reflect the impact of the earthquake on the original facility and others reflect the impact of the earthquake on the current operations of the temporary facility. While every attempt was made to have the respondent focus their assessment of the impact of the earthquake on the original facility, the responses to some of the questions suggest that some respondents may not always have been able to do so.

The first part of the questionnaire asked about the type of problems they experienced. These included whether the earthquake caused problems with staffing, lead to a loss of water, electricity, communications, heating and medical gases as well as damage to a list of nonstructural elements. For many of the questions, the respondents were asked to indicate how long the problem persisted and to provide additional information about the problems encountered with an open-ended response category. The responses of the study participants to the open-ended portion of the questionnaire are presented first, followed by their responses to the closed-end question.

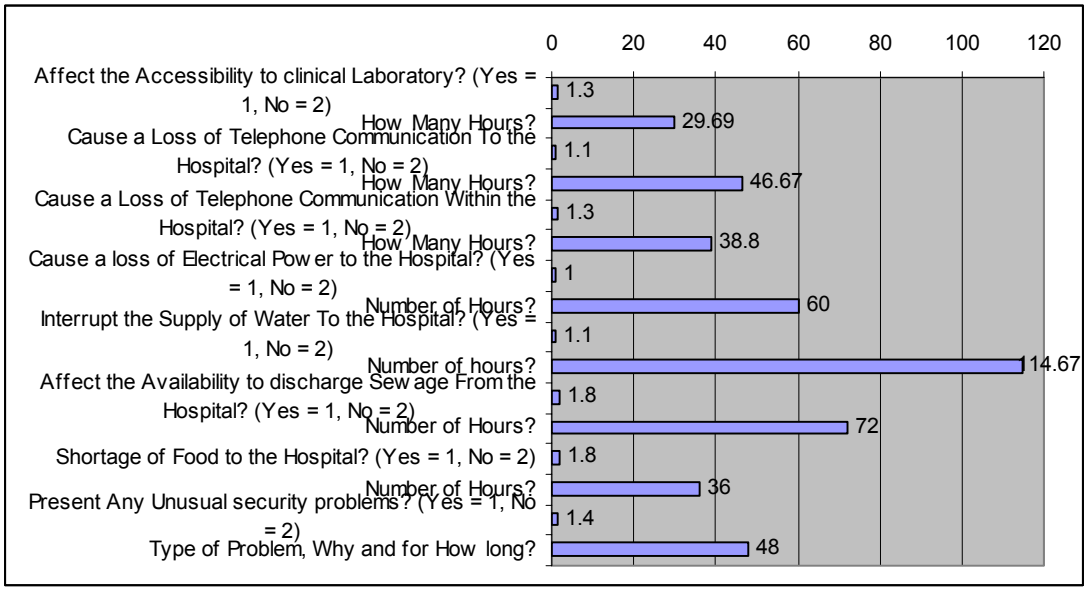
Figure 1. The Impact of the Izmit Earthquake on the Functionality of the Hospitals



In Figure 1, the results of the open-ended assessments of the impact of the earthquake on the functioning of the hospitals are reported. All of the hospitals reported staff deaths that resulted from the earthquake. The major conditions affecting the functionality of the hospitals were the inability of key staff to report to duty and the loss of telephone communication to the hospital. Loss of electrical and water services also presented problems which were exacerbated by the failure of the backup power supply.

The closed-ended portion of the questionnaire contained a list of life-line and nonstructural elements. The respondents were asked to review this list and indicate whether the earthquake affected that particular component, and if so, for how long. All of the respondents reported that the earthquake had an impact on the availability of key hospital staff, damage to ceilings and ceiling tiles, damage to partitions and a loss in electrical power. Over 25 percent of the hospitals' emergency treatment staff were not available because of the earthquake. Restoring the water supply to the hospitals took an average of 114 hours. On average, it was 3 days before hospitals were able to discharge their sewage. It took almost as much time (60 hours, on average) before power to the hospitals was restored. Telephone services took one to two days to be restored. Gaining access to key departments such as the laboratory took over 24 hours, on average to achieve (Figure 2; Also see USC 2000c for complete results).

Figure 2. The Impact of the Izmit Earthquake on the Availability of Staff, Supplies and Equipment (Average Scores) (0=N/A)[3]



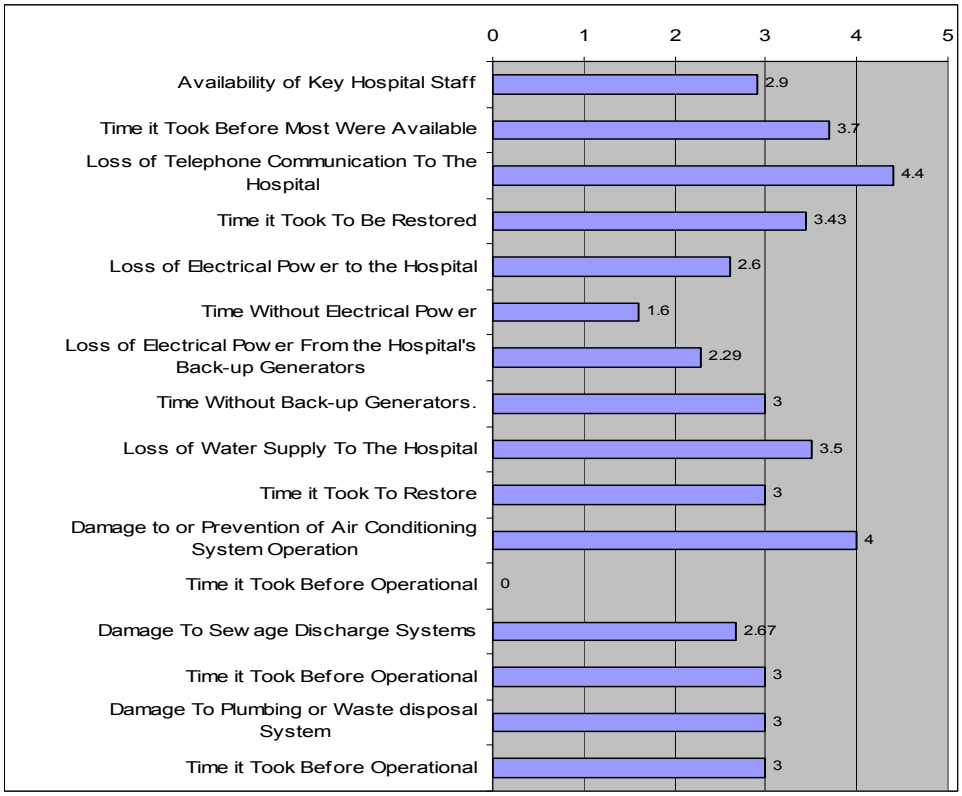
A second set of questions asked the respondents to indicate, using a 5-point Likert scale, the impact that the damage to the life-line and nonstructural systems had on the operation of their hospital. They reported that the loss of communication to the hospital had the greatest impact on their ability to function. Nearly as significant was the damage to the air conditioning system. The loss of water and damage to the waste disposal systems also presented significant problems on the hospitals' functionality. Also important in terms of the impact on the functioning of the hospital were the time it took before staffs were available and before the telephone system was back in operation (Figure 3; Also see USC 2000c for complete results).

The respondents also reported that the damage to life-line and nonstructural systems had a limited impact on certain areas or functions of the hospital. They reported that the earthquake had limited impact on the following: Damage to computer terminals; Hazmat incidents or problems; Damage to fire alarm systems; Damage to stairs or fire escapes; Damage to lights or light systems; Damage to critical hospital records; Loss of water supply within the hospital even though the external supply was interrupted; Damage to or the prevention of the heating system from operating; Damage to emergency lighting systems.

A third part of the survey asked the respondents to indicate how critical, a key hospital service delivery unit was to the functioning of a hospital at different points during and following an earthquake. These points in time were characterized as: Phase I was immediately following the earthquake; Phase II was described as a stabilization of operations; Phase III was defined as the recovery and cleanup phase; and Phase IV, reflected a transition to normal operations.

[3] Due to space limitations only those items that were out of service for more than 24 hours were reported.

Figure 3 The Impact of Earthquake Related Problems or Conditions on the Operation of the Respondent's Hospital (Time= # of Days, 0=NA, 1= No Impact 5= Very Great Impact)[4]

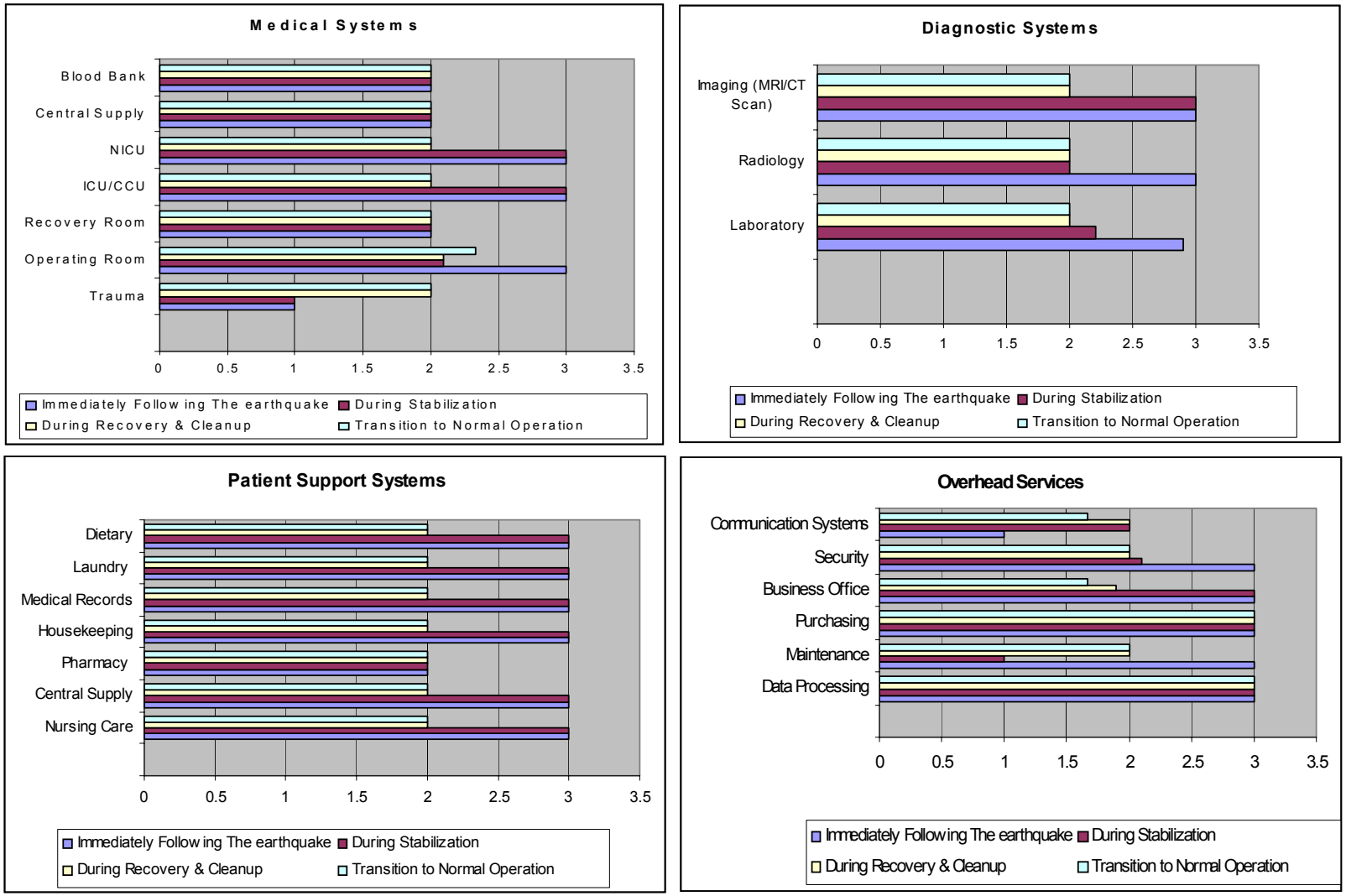


Each respondent was given a list of key departments along with spaces where they could add departments that were not included in the list provided. They were asked to review the four phases of the earthquake and to indicate how critical each department was to the functioning of the hospital at each phase. Four response categories were available. The first was "Essential", which was defined as "A department whose functioning is essential in the described situation". The second was "Important" which was defined as "A department whose functioning is important, but not essential, in the described situation". The third was "Useful" which was described as "A department whose functioning is useful but not important in the described situation. The last category was "Not Applicable" which was characterized as "a department that is not needed in the described situation".

A summary of the average response scores is presented in Figure 4. In scoring the responses, a "1" was the value assigned to essential services or departments, a "2" was assigned to important department or service, a "3" was assigned to useful department or services. No value was associated with departments listed as not needed in the described situation.

[4] Due to space limitations only those items with a 2.5 or higher value were reported.

Figure 4: The Importance of Key Departments and Services over the Life Cycle of an Earthquake



Two systems, Trauma and Communications, were described as essential to the operations of the hospital immediately following an earthquake. This pattern changes somewhat during the stabilization phase where Maintenance becomes essential along with Trauma. However, no service is seen as Essential during the Recovery and Clean-up phase and the Transition to Normal Operations phase.

In contrast, 16 of the 24 systems were regarded as "useful" immediately following the earthquake. This number declines to 12 during the stabilization phase with only two departments – data processing and purchasing – continuing to be seen as "useful" in the "recovery" and "transition" phases.

Conclusions: Hospital Performance

This study used information from survey data obtained from key hospital and medical personnel of 10 public hospitals in Turkey about the performance of their hospitals and critical care facilities. Findings were used to identify critical nonstructural systems, essential hospital departments, and the diagnostic and treatment equipments necessary to sustain functionality of a hospital or a critical care unit during or following a major seismic event.

Findings suggest that the functionality of hospitals is influenced by a number of different factors. First, the severity, proximity and duration of seismic forces have a major impact on the extent which structural components were able to resist damage. Second, functionality of all hospitals is influenced by the seismic standards governing the construction of the facilities and their enforcement as well as the age and type of construction of the facilities as empirically demonstrated by the studies on Northridge and Loma Prieta earthquakes (USC, 2000).

Our survey findings also reveal that, even if the structural components were intact, nonstructural failures in the facilities had remarkable effects on the functioning of hospitals following an earthquake. Interruptions of water, sewage, electrical and telephone services to the hospital were a major factor limiting hospitals' functioning. While most hospitals had back up capacity, structural and nonstructural damage often hindered the operation of back up systems. Consistent with other findings, most of the damage to the functioning of the hospitals was caused by the failure of supply systems rather than by damage to a particular piece of equipment (2000b). These findings were also confirmed in similar studies in California and Japanese hospitals after major earthquakes (USC, 2000). Pipe failures, particularly water lines, severely limited the functionality of hospitals in most cases. However, an interesting finding in the Turkish case was that the existence of water wells in some facilities reduced the possible interruptions that might result from the damage to the municipal piping systems.

Interruptions in the communications and transportation systems as well as the damage to the cities' infrastructure limited hospitals' access to staff, information, supplies, and services. During the early hours of the earthquake, sudden increases in the number of drivers and telephone calls crippled the communication and transportation lines. While the hospitals, through the initiative and improvisational skills of their staffs were able to function in spite of the damage, the lack of information about the extent of the damage in the area; questions about the structural integrity of the building; and, uncertainties over the state of critical systems hindered the functionality of the hospitals during and following the Izmit earthquake and its aftershocks.

In addition to the structural and nonstructural failures, uncertainty and information isolation were the next group of factors that hindered the functionality of the hospitals. Especially during the early hours of the catastrophe, TVs and mobile phones, when they were not jammed, had a pivotal role in overcoming the uncertainty and information isolation.

The implication for managers and policy makers is that earthquake mitigation and preparedness requires consideration of both internal and external elements of a health system influenced by the earthquake as well as the structural and nonstructural components of the hospitals.

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