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Development and Evaluation of Management Programs to Reduce the Average Length of Stay (LOS) in Emergency Departments (ED)

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Abstract

Objectives: To examine the effectiveness of a computer-based Emergency Auto-Consultation System (EACS) in reducing additional LOS caused by specialty consultation. **Methods/Statistical Analysis**: Data collection and investigation of electronic records gathered during the six months periods before and after the implementation of the Emergency Medical Center residency management program (April-September 2012 and October 2012-March 2013, respectively). The collected data were analyzed using the SPSS (Statistical Package for Social Sciences) 18.0 program which uses descriptive statistics, 2-test, t-test, ANOVA, and ANCOVA. **Findings**: The total number of subjects was 40,578 patients; the control group consisted of 20,982 patients and the experimental group consisted of 19,596 patients. The control group was 50.2% male and 49.8% female. The emergency medicine department was the most common department (36.1%). According to a triage classification tool, semi-emergencies (87.6%) were the most common in the population. Additionally, 99.7% of patients did not receive CPR, and 99.5% of patients did not receive ventilator treatment. On the other hand, the experimental group was 48.4% male and 51.6% female. The emergency medicine department was the most common department (36.6%). According to a triage classification tool, semi-emergencies (85.8%) were the most common in the population. Also, 99.7% of patients did not receive CPR, and 99.4% did not receive ventilator treatment. The control group's average LOS in ED was 130.53 min±107.87, and the experimental group's LOS was 114.48±93.42. This indicates a statistically significant shortening of LOS (F=380.450, p<.001). **Improvements/Applications**: Reducing the average LOS in emergency by reducing the bed occupancy rate and overcrowding will increase patient satisfaction.

Keywords: Emergency Department, Emergency Room, Length of Stay, Management Program

1. Introduction

The term "Emergency Medical System" refers to the organizational structure that is established to transfer or treat medical patients as soon as possible when an emergency occurs due to unexpected accidents or unforeseen illnesses[1].

It can be said that the most important characteristic of an emergency patient is that, unless immediate treatment takes places, the patient is at risk of losing his life or suffering permanent major organ damage. In particular, since the time until the first treatment after emergency symptoms occur is known to be a major factor influencing the prognosis, we can say that temporal disturbances in emergency medical care are the most important factor[1].

However, the phenomenon of emergency medical institution overcrowding due to the increase of emergency medical demand is a problem which is drawing attention worldwide, not only South Korea[2]. The phenomenon of eemergency medical institution overcrowding increases

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the patient's residence time, thus increasing patient dissatisfaction with medical treatment. It also inhibits the ED's ability to respond quickly to emergency situations and increases the workload burden on the resources of the Emergency Medical Center[2,3]. So Length Of Stay (LOS) is an important measure of the quality of care in the Emergency Department (ED)[4].

Many hospital-based EDs across the country have been struggling with overcrowding for more than a decade[5]. The ones who are hurt most due to inefficient ED systems are the patients who use the ED. In spite of the fact that all emergency patients should be able to receive prompt and appropriate treatment, under the current circumstances, patients with high-severity conditions suffer from delayed treatment decisions and increased risks of worsened prognoses, while patients with low-severity conditions suffer from unnecessary cost burdens caused by service delays[6].

According to previous studies related to the residence time of patients in emergency medical centers, total residence time averages of 3.4 hours[7], 4.04 hours[8], 6 hours[9] and even 17.6 hours[10] have been reported, indicating the severity of the problem of delays in treatment. The main factors that affect the residence time in emergency medical centers are delays in clinical treatment and delays in therapeutic decision making[8,9].

The ones who suffer most due to the inefficient systems of emergency medical centers are the patients who use Emergency Medical Centers. Even though all patients are entitled to receive quick and proper treatment at Emergency Medical Centers, under the current circumstances, patients with severe conditions suffer from delays in decision-making and increased risks of worsened prognoses while patients with less severe conditions must bear the unnecessary costs associated with the delays in service[6].

Therefore, the present study was conducted to develop management programs to reduce the average LOS in ED and to evaluate such programs.

2. Proposed Work

2.1 Methods

2.1.1 Study Design

This research was designed as a pre-test/post-test study which uses a simulated control group in order to develop a residence time management program for Emergency Medical Centers and to measure the effectiveness of that program.

2.1.2 Study Subjects, Data Collection Procedure and Ethical Considerations

The data was collected via EMR at "C" university hospital. All data used was collected according to the approved guidelines and screening procedures of "Chung University" located in Seoul. All experiments of the present study were also approved by the Institutional Review Board [IRB No: 201319C979] at "C" University. This data will never be used for any purpose other than this research.

The subject of the present study is the emergency medical center residence times of patients who visited the area Emergency Medical Center. In order to verify the effectiveness of the program, the residence times of the patients who visited the EMC during the period of April-September 2012 were used as the control group, and the residence times of patients who visited the EMC during the six months after the implementation of the residence time management program (from October 2012-March 2013) were used as the experimental group. In this analysis of residence times, the control group consisted of 20,982 subjects, and the experimental group consisted of 19,596 subjects.

2.2 Measures

2.2.1 Develop of the ED Residence Time Management Program

Starting from October 2012, the first step taken was the construction of a task force team to solve the problems which cause delayed LOS in ED. The team included the following positions: medical director, nursing director, medical faculty, ED director, and ED head nurse. Practically, we had to get rid of limited admission hours for the general ward, switch to a system of 24-hour hospitalization, and run an intensive care unit in the ED. Also, emergency PCI procedures which involved the internal medicine physician on-call were switched to a system involving the cardiology physician on-call.

In the neurology department, the system for calling residents to treat emergency patients (such as those who have suffered an acute stroke) was modified to call 2nd-year residents instead of busy 1st year residents. In the neurosurgery department, changes were implemented so

that patient results could be confirmed quickly, allowing for prompt hospitalization instead of extended stays in the ED. Additionally, changes were implemented so that patients who have waited for more than three hours since admission to the ED were marked in red in the EMR, thus allowing all medical staff members to be aware of their situations and residence times.

In addition, each clinical department provided a daily list of 4 residents and 1 specialist as the doctors-on-duty. The ED doctors then used the Emergency Auto-Consultation-System (EACS) to contact the departments required for a specialty consultation; clicking the department's name on the computer screen activated the Short Message Service (SMS) calling system, which sent a message with the registration numbers and names of the relevant patients every 15 minutes to the mobile phones of individuals assigned as doctors-on-duty, in the order listed. The doctors who received the SMS were asked to arrive at the ED within 10 minutes. If the doctor-on-duty who was listed first did not show up within 10 minutes, an SMS was sent to the next group of doctors-on-duty on the list. Withinn 50 minutes, therefore, the entire group of five doctors-on-duty would have received the SMS in the order listed. Each clinical department estimated the response time of their doctors-on-duty two months before and after the adoption of the EACS. A comparison was also made between the LOS of patients admitted to the ED before and after the adoption of the EACS. A questionnaire was used to survey the health professionals working in the ED about the changes in the intensity of labor and the needs of the EACS.

2.3 The Length Of Stay (LOS)

The residence time questionnaire, which was written to evaluate the time reduction effect of the program on total residence times (from admission until the decision to admit or discharge the patient) was set up as follows. The reception of the patient to the Emergency Medical Center was set as the starting point; the time it took the patient to be called to, visit with, and leave each resident was measured (thus giving the total residence time); and the time taken was at each stage was measured in minutes.

2.3.1 Severity Classification of Emergency Department Patients

In the present study, each patient's severity was classified according to the Emergency Triage tool developed by[11] Patients are classified into the following groups: urgent (grade 1), emergency (grade 2), semi-urgent (grade 3), and non-emergency (grade 4). Urgent patients require emergency treatment within a few minutes to a few hours; emergency patients require emergency treatment within a few hours; semi-urgent patients present severe acute symptoms but show no large abnormalities in their vital signs; and non-emergency patients can receive treatment within a few hours or a few days without any effects on survival. In this classification system, the highest rating indicates the least severe condition.[6]

2.3.2 General Characteristics of the Subjects

The subjects were classified according to the following seven characteristics: gender, age, department of diagnosis and treatment, severity, type of discharge, whether cardiopulmonary resuscitation was required, and whether artificial respiration therapy was required.

2.3.3 Data Analysis

The collected data was managed and analyzed using the Statistical Package for Social Sciences software version 18.0 (SPSS, Chicago, IL, USA). Descriptive statistics were calculated, including the frequency, mean, and standard deviation. Patterns in the differences among study participants were analyzed with descriptive statistics, t-test, ANOVA, and ANCOVA.

3. Results

3.1 Validation of Homogeneity of the General Characteristics of the Subjects

The Table 1 shows the validation of homogeneity of the general characteristics of the subjects.

Homogeneity of the general characteristics of the subjects were as follows: gender ($p = .001$), age ($p < .001$), department ($p < .001$), severity ($p < .001$), type of discharge ($p < .001$), whether CPR was performed ($p = .318$), and whether ventilator care was performed ($p = .310$).

The total number of research subjects was 40,578 patients; the control group consisted of 20,982 patients, and the experimental group consisted of 19,596 patients. The control group was 50.2% male and 49.8% female. The emergency medicine department was the most common department (36.1%). According to the triage classification

Table 1. Validation of homogeneity of general characteristics

Variable	Categories	Control group (N=20,982)		Experimental group (N=19,596)		χ^2	p
		n	%	n	%		
Gender	Male	10,526	50.2	9,492	48.4	12.109	.001
	Female	10,456	49.8	10,104	51.6		
Age	0~10	5,248	25.0	4,323	22.1	59.319	<.001
	11~20	1,694	8.1	1,524	7.8		
	21~30	3,455	16.5	3,273	16.7		
	31~40	2,763	13.2	2,655	13.5		
	41~50	1,946	9.3	1,913	9.8		
	51~60	2,242	10.7	2,208	11.3		
	Over 61	3,634	17.3	3,700	18.9		
Department	Emergency medicine	7,573	36.1	6,984	36.6	31.249	<.001
	Internal medicine	1,651	7.9	1,664	8.5		
	Surgical	4,155	19.8	4,057	20.7		
	Pediatrics	3,653	17.4	3,042	15.5		
	Neurology	973	4.6	1,027	5.2		
	Other	2,977	14.2	2,833	14.1		
Severity	Non-emergency (Grade 4)	1,337	6.4	1,380	7.0	33.342	<.001
	Semi emergency (Grade 3)	18,390	87.6	16,808	85.8		
	Emergency (Grade 2)	1,184	5.6	1,325	6.8		
	Urgent (Grade 1)	71	0.3	83	0.4		
CPR	No	20,925	99.7	19,532	99.7	1.029	.318
	Yes	57	0.3	64	0.3		
Ventilator care	No	20,877	99.5	19,472	99.4	1.029	.310
	Yes	105	0.5	124	0.6		
Type of discharge	Return home	16,447	78.4	14,666	74.8	103.934	<.001
	Transfer	126	0.6	79	0.4		
	Admission	3,585	17.1	4,066	20.7		
	Death	51	0.2	51	0.3		
	Self-discharge	752	3.6	696	3.6		
	DOA	12	0.1	16	0.1		
	Other	9	0.0	22	0.1		

tool, semi-urgent cases (87.6%) were the most common in the population. Additionally, 99.7% of patients did not receive CPR, and 99.5% of patients did not receive ventilator treatment. On the other hand, the experimental group was 48.4% male and 51.6% female. The emergency medicine department was the most common department (36.6%). According to the triage classification tool, semi-urgent cases (85.8%) were the most common in the population. Also, 99.7% of patients did not receive CPR, and 99.4% did not receive ventilator treatment.

The Table 2 shows the difference in residence times according to the general characteristics of the subjects.

In the control group, residence times for females were longer than those for males. Residence times for subjects

over age 61 were the longest compared to those for other age groups. By department, the ranking of residence times was as follows (longest to shortest): internal medicine, neurology, surgical, other, pediatrics, and emergency medicine. By severity, the longest residence times were for semi-emergency patients; urgent patient residence times were the shortest. The presence or absence of cardiopulmonary resuscitation caused no differences in

Table 2. Differences in residence times according to general characteristics

Variable		Source	SS	df	MS	F	p
Response time	Call time	Modified model	436396.837	3	145465	246.565	<.001
		Severity	68972.892	1	68972.892	116.909	<.001
		Age	238075.862	1	238075.862	403.539	<.001
		Group	40585.283	1	40585.283	68.792	<.001
		Error	23936841.33	40573	589.970		
		Total	24373238.17	40576			
	Visit time	Modified model	293086.226	3	97695.409	75.686	<.001
		Severity	110738.733	1	110738.733	85.791	<.001
		Age	99572.390	1	99572.390	77.140	<.001
		Group	128402.391	1	128402.391	99.475	<.001
		Error	52371714.91	40573	1290.802		
		Total	5266481.14	40576			
Discharge time		Modified model	61133943.5	3	20377981.18	2061.777	<.001
		Severity	13486821.90	1	13486821.90	1364.552	<.001
		Age	33391287.82	1	33391287.82	3378.420	<.001
		Group	1800655.931	1	1800655.931	182.184	<.001
		Error	101021219.0	40574	9883.699		
		Total	462155162.5	40577			
Length of stay in ED		Modified model	53943340.9	3	179811113.64	2005.265	<.001
		Severity	9245671.464	1	9245671.464	1031.083	<.001
		Age	3143128.65	1	31364128	3505.554	<.001
		Group	3411472.028	1	3411472.028	380.450	<.001
		Error	363825054.9	40574	8966.951		
		Total	417768395.8	40577			

Table 3. Analysis of covariance

Variable	Categories	Control group (N=20,982)		Experimental group (N=19,596)	
		M±SD	F or t(p)	M±SD	F or t(p)
Gender	Male	127.99±107.38	-3.167 (.002)	114.01±92.746	-.412 (.680)
	Female	132.72±132.72		114.56±94.27	
Age	0~10	85.85±71.76[f]	448.481 (<.001)	76.11±52.56[e]	312.961 (<.001)
	11~20	110.71±90.12[e]		104.24±90.89[d]	
	21~30	117.92±91.94[d]		104.74±74.50[d]	
	31~40	127.22±101.50[d]		111.02±90.46[c]	
	41~50	149.93±115.09 [c]		126.57±95.29[b]	
	51~60	153.93±117.32[b]		128.00±93.39[b]	
	Over 61	192.92±130.49[a]		159.34±122.41[a]	

Department	Emergency medicine	96.76±69.30[d]	985.030 (<.001)	86.26±55.59[d]	782.554 (<.001)
	Internal medicine	245.65±131.32[a]		201.33±145.22[a]	
	Surgical	152.17±113.17[b]		134.63±100.67[b]	
	Pediatrics	97.07±81.01[d]		88.41±57.617[d]	
	Neurology	231.80±133.661[a]		192.83±119.75[a]	
	Other	129.05±114.24[c]		102.45±84.96[c]	
Severity	Non-emergency (Grade 4)	118.80±89.57[b]	383.592 (<.001)	123.13±143.28[b]	397.459 (<.001)
	Semi-emergency (Grade 3)	205.90±138.83[a]		172.90±107.80[a]	
	Emergency (Grade 2)	130.38±104.85[b]		114.71±91.47[b]	
	Urgent (Grade 1)	63.59±69.67[c]		52.48±53.16[c]	
CPR	No	112.09±72.40	-1.903 (.062)	114.17±93.25	.462 (.646)
	Yes	130.40±108.07		123.50±93.245	
Ventilator care	No	130.01±107.54	4.147 (<.001)	113.83±93.03	6.106 (<.001)
	Yes	196.84±164.96		187.92±134.91	
Type of discharge	Return home	107.22±81.93[bc]	827.855 (<.001)	95.21±67.72[d]	517.751 (<.001)
	Transfer	233.67±136.16[a]		225.01±168.67[a]	
	Admission	231.09±144.76[a]		178.19±131.34[b]	
	Death	93.67±50.12[c]		86.55±65.02[d]	
	Self-discharge	142.32±113.85[bc]		136.23±107.63 [c]	
	DOA	20.42±8.99[d]		22.88±30.31[e]	
	Other	166.00±144.16 [b]		66.23±62.35[d]	

residence times, but if artificial respiration was carried out, it resulted in longer residence times. With regard to type of discharge, the longest residence times occurred in the case of transfers to another hospital; the case of DOA led to the shortest residence times.

In the experimental group, residence times did not differ significantly according to sex. Residence times for subjects over age 61 had the longest residence times. By department, the ranking of residence times was as follows (longest to shortest): internal medicine, neurology, surgical, other, pediatrics, and emergency medicine. The ranking according to severity was as follows (longest to shortest): semi-emergency, non-emergency, emergency, and urgent. The presence of cardiopulmonary resuscitation did not cause significantly longer residence times, but artificial respiration did result in longer residence times. With regard to type of discharge, the ranking was as follows (longest to shortest): transfer, admission, self-discharge, return home, death, other, and DOA.

The analysis of covariance was carried out for age and severity and showed a statistically significant difference in the homogeneity test. Each modified model--contact time with residents ($F = 246.565$, $p < .001$), department visit time ($F = 75.686$, $p < .001$), check-out time ($F = 2061.777$, $p < .001$), and total residence time ($F = 2005.265$, $p < .001$) was determined to be a valid model as shown in Table 3.

The Table 4 shows both the response times of the doctors-on-duty and the control group's results versus the experimental group's results, which were as follows: doctor's call time, 20.11±26.84 to 17.91±21.68 ($F=68.79$, $P<.001$); and ddoctor's visit time, 17.45±40.59 to 143.97±13.95 ($F=99.475$, $p<.001$). The total doctor's response times were as follows: the control group's average LOS in ED was 130.53±107.87, and the experimental

Table 4. Comparison of lengths of time between subject groups according to response times of doctors-on-duty

Time		Control group (N=20,982)		Experimental group (N=19,596)		F	p
		Mean	SD	Mean	SD		
Response time	Call time	20.11	26.84	17.91	21.68	68.792	<.001
	Visit time	17.45	40.59	13.97	13.97	99.475	<.001
Discharge time		93.65	114.23	82.74	97.73	182.184	<.001
Length of stay in ED		130.53	107.87	114.48	93.42	380.450	<.001

Table 5. Comparison of lengths of time between subject groups according to severity

Time		Severity	Control group (N=20,982)		Experimental group (N=19,596)		F	p
			Mean	SD	Mean	SD		
Response time	Call time	Urgent	.48	6.99	.13	2.42	.223	.638
		Emergency	2.91	5.78	2.74	5.54	.420	.517
		Semi-emergency	21.82	27.93	19.63	19.46	64.294	<.001
		Non-emergency	13.05	13.02	12.65	41.59	.038	.845
	Visit time	Urgent	.69	5.81	.10	.617	.990	.321
		Emergency	4.04	47.65	2.01	10.38	2.126	.145
		Semi-emergency	18.85	41.06	15.41	29.84	86.781	<.001
		Non-emergency	10.89	20.47	8.73	43.40	3.291	.070
Discharge time		Urgent	117.86	81.553	123.23	143.19	.064	.801
		Emergency	201.44	146.57	168.23	108.112	44.253	<.001
		Semi-emergency	90.52	110.50	80.02	95.557	136.896	<.001
		Non-emergency	39.97	64.42	31.37	46.28	19.859	<.001
Length of stay in ED		Urgent	119.03	89.440	123.46	143.13	.038	.845
		Emergency	205.96	138.787	172.98	107.73	46.786	<.001
		Semi-emergency	130.56	104.718	114.90	91.358	308.543	<.001
		Non-emergency	63.90	69.58	52.75	53.10	26.482	<.001

group's was 114.48±93.42. This indicates a statistically significant shortening of LOS (F=380.450, p<.001).

By severity, the control group's results versus the experimental group's results were as follows: urgent, 119.03±89.44 to 123.46±143.13 (F=.038, p=.845); emergency, 205.96±138.79 to 172.98±107.73 (F=46.786, p<.001); semi-emergency, 130.56±104.72 to 114.90±91.36 (F=308.543, P<.001); and non-emergency, 63.90±69.58 to 52.75±53.10 (F=26.482, p<.001). Except for urgent cases, there were statistically significant differences as shown in Table 5.

The residence time significantly decreased both the response times of doctors-on-duty (34.8±35.5 min vs. 9.7±16.8 min, p<.001) and the LOS (155.3±126.7 min vs. 144.6±110.7 min, p=0.003).

4. Discussion

This research attempted to evaluate the effects of management programs to reduce the average Length Of Stay (LOS) in Emergency Departments (ED). In this study, the average time between the patient's initial ED visit and

contacting a resident was 17.91 minutes, a significant reduction of 2.2 minutes; the average time until the resident's arrival was 13.97 minutes, a significant reduction of 3.48 minutes. Also, the average time between the resident's response and the ED patient's discharge was 82.74 minutes, a significant reduction of 10.92 minutes. Finally, the average LOS in ED (the time between the patient's initial ED visit and the patient's discharge from the ED) was 114.48 minutes, a significant reduction of 16.05 minutes. Kim et al.'s study on examining the effectiveness of a computer-based emergency auto-consultation system reported a significant time decrease of 10.7 minutes[12].

In contrast with studies such as Kim et al.'s study[12], which was conducted using only a one-way system with an auto-consultation system, in the present study, the program was applied to build a cooperative system which includes various domains. Thus, it is considered that it is possible to shorten more time.

The major causes of delays in emergency medical center residence times were considered to be delays in treatment decisions[13,14] and delays in attending physician visiting times[8,13]. However, according to Cheon's study, attending physician answering times and admission/discharge decisions were more likely to delay residence times in emergency departments.

In this study, the elapsed time from the intern's initial treatment until contact with a resident was 17.91 minutes. The elapsed time from resident contact until the residents visit was 13.97 minutes. The elapsed time from the patient's initial visit to the hospital until meeting a resident was 31.88 minutes; this was a significantly shorter result than the 51.73 minutes recorded in study[15]. Although the shortening of residence times in each stage is important, it is also possible to know that shortening resident response times to patients has the effect of significantly reducing residence delays.With regard to patient severity, application of the management program was effective in reducing the residence times of all severity grades except for the times of urgent patients. In the case of urgent patients, discharge times and total residence times were not affected by the application of the management program.

Such results appeared because emergency patients often require many co-consultation requests and additional examinations; waiting for the test results to come out makes it likely that residence times will be delayed. Additionally, due to their unstable conditions, patients are often required to remain in the emergency medical center until their conditions stabilize, thus inevitably causing delays in discharge times. This was similar to the findings of study[15].

We found that the ED management program effectively reduced resident calling times, visiting times, patient discharge times, lengths of stay in the ED, and total residence times. However, depending on patient severity, the program was found to be partially effective. Therefore, to enhance the effectiveness of shortening residence times, it is necessary for medical centers to strategically provide additional resources, integrated support, and steady efforts to allow the program to become established.

However, it can be noted that previous studies only looked at the effects of applying one computer-based emergency auto-consultation system; in contrast, this study shows that even more time reductions can be achieved by applying management systems in various areas.

5. Conclusion

The development of residence time management programs at emergency medical centers will be able to decrease patient residence times; this will have the practical effect of improving the quality of patient care and services in clinical practice. In addition, due to the close relationships between residence times the issues of overcrowding and bed occupancy rates, shortening residence times can mitigate the extent of overcrowding and increase bed occupancy rates at emergency medical centers. Enhancing the satisfaction levels of patients and caregivers who visit the ED can greatly improve both the image and the profitability of the hospital.

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