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Analysis of external environmental factors affecting patient transport time

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Abstract

Emergency transport is directly related to the life of the patient, and rapid transport to the hospital is crucial. However, external environmental factors such as traffic or weather, interfere with hospital transport. In this study, we investigated the external environment affecting hospital transport time. We examined the transfer time and patient treatment time of emergency patients in an area of northern Gyeonggi-do from 2018 to 2020. Diagnosis after arrival at the hospital was used, and on-site treatment time was measured from paramedic arrival time at the scene to departure. Furthermore, we examined whether there was a correlation between the time paramedics left the scene and hospital arrival time through the reason for the delay as recorded in the emergency log. Traffic jams had the greatest impact on patient transport, while transport delays occurred due to heavy rain, but not snow. Among injured patients, electrical accidents were the most problematic in terms of on-site treatment time. This was because a lot of first aid is needed in electrical accidents. It must be necessary to mobilize two ambulances in an emergency through the expansion of infrastructure, prepare a plan for rapid transport in heavy rain, and implement strong laws against transport obstruction.

Keywords: Emergency Patient, Patient Transfer, Golden Hour, Injury, Electrical Accident

Major classifications: Health Science, Public Health

1. Introduction

Life expectancy is increasing worldwide. However, life expectancy has changed a lot since COVID-19(Scholey et al., 2022; Urashima et al., 2022). The main causes of the increase in life expectancy are socioeconomic factors and healthy lifestyles,

as well as early detection of diseases. In addition, a clean sanitary environment and changing lifestyles, including diet control and exercise to control obesity and prevent diabetes has improved life expectancy. Also, people are now managing their health better by measuring their blood sugar and blood pressure at home. As a result, life expectancy is gradually increasing. However, an increase in life expectancy poses the risk for various geriatric diseases(Lunenfeld & Stratton, 2013). Geriatric diseases are typically metabolic diseases. Metabolic diseases include diabetes, high blood pressure, arteriosclerosis, which pose as risk factors for various complications. In particular, vascular diseases such as arteriosclerosis can cause myocardial infarction and cerebral infarction, as well as myocardial infarction. Contrary to our perception, the aging of the population is not a problem caused by an increase in the elderly population, but a problem caused by the coexistence of a low fertility problem. The low fertility rate and aging population pose the problem of a decrease in the labor force and cause social problems such as a decrease in the labor force and an increase in medical expenses. In addition, emergency patients are increasing as the elderly population increases (George et al., 2006). According to the Statistical Yearbook of the National Fire Service in 2021, the number of dispatches in 2020 was 2,766,136, and the number of transferred patients was 1,621,775. Among them, the number of dispatches to Seoul and Gyeonggi-do accounted for 40% of the total dispatches. Based on the 119-ambulance transfer status log, 60% of all transferred patients were over 50 years old. Through this, more patients can be expected due to the aging trend of the population described above. In addition, among the diseases transport by emergency, cardiovascular and cerebrovascular diseases are mainly transport to the elderly. However, in the case of injury, regardless of age, it occupies a large part. In the case of trauma injury, it occurs more often in those under 40 years of age (Cho et al., 2005).

In the Republic of Korea, the number of incidents related to emergency transportation continues to increase. For instance, an incident occurred in April 2021 in which a taxi driver blocked an ambulance transferring an emergency patient, causing an accident. The patient died due to the accident, and the court ordered 30 million won in compensation. In another case, an issue arose in selecting the hospital, and treatment was delayed, resulting in an accident after which a leg was eventually amputated due to formation of an embolism blocking a blood vessel. Therefore, in an injury caused by a traffic accident, prompt treatment is important. According to Lee Jung-ho's 2018 thesis related to ambulance traffic accidents, 207 of 451 subjects had an accident, and 69 of them were in transit. It is well known that prompt treatment is important when transporting a patient. The golden time is when an appropriate treatment time is presented according to the patient's condition. The first reference to the golden time appeared during World War I regarding the importance of transport according to the condition of the patient, and it was called the golden hour (Fischer & McDonough, 2015; George et al., 2006; George & Quattrone, 1991; Izmaylov, 2021; McNicholl, 1994; Yen & Parrillo, 2008).

Each emergency condition has a different golden hour, and, in particular, myocardial infarction and stroke, which are directly related to survival outcome, consider one hour as the crucial period. However, this is an average time and may vary depending on the patient's age, medical condition, etc. In addition to this, guidelines have been established for several conditions (Lawton et al., 2022).

i. Patients with severe injury must enter the operating room within one hour.
ii. Cardiopulmonary resuscitation should be initiated within four minutes of cardiac arrest.
iii. In the case of myocardial infarction, the probability of death increases by 20% for every hour that passes.
iv. In the case of coronary artery occlusion, myocardial necrosis occurs after 30 minutes.
v. Immediate transfer to a hospital for cerebrovascular disease patients.
vi. Intoxication or metabolic disorders require prompt treatment.

However, these guidelines may vary depending on the patient's individual condition, the underlying pathology, and the severity of the disease, and it is difficult to know the exact golden hour duration owing to multiple variables, especially in the case of elderly patients.

When considering the age of patients requiring emergency transfer, patients over the age of 61 account for more than 40% of the total number of emergency patients. Additionally, patients over the age of 50 account for 60% of all transfers. According to Statistics Korea data for 2020, the population in their 50s and above represents 41% of the total population. We investigated the causes of death by age through data obtained from the Korea Medical Insurance Corporation. It was found that the greatest change was in the <40 years and >40 years age groups. When we look at the overall causes of death, heart disease ranks among the top five causes of death for all age groups. For those >40 years, heart disease ranks second, cerebrovascular disease third, followed by pneumonia and liver disease. Emergency patient transport is important, and many advances are being made. The 119 Ambulance is moving quickly, but there are still many shortcomings. There are several reasons for transport patient delays. In previous studies, the reason for delay in transfer of emergency patients was that the

disease was detected late (Lee & Moon, 2020), and wearing personal protective equipment for COVID-19 (Park et al., 2022).
In this study, we want to find out the causes of delay in transporting emergency patients. We investigated whether external environmental factors (traffic, climate, accidents and trauma) affect the patient's transport delay and suggest a method for rapid transport.

2. Methods

The study participants were patients who were transferred to the hospital by 119 paramedics in Pocheon-city, northern Gyeonggi-do between January 2018 to December 2020. A total of 19 diseases or emergency conditions were classified. The average transfer time was analyzed for a total of 21,319 transferred patients. Further, discrepancy in transfer time due to transfer delay, heavy rain, heavy snow, traffic jam, or hospital selection, was analyzed based on the emergency log data. The required time was calculated from the time taken from the patient's report time to the hospital arrival time. This study was conducted with prior approval from the IRB of Eulji University (EUIRB2021-034). This study was analyzed by frequency analysis and t-test using SPSS 18. The independent variable was the reason for the transfer, and the dependent variable was set to time.

3. Results

The population of Pocheon-city in northern Gyeonggi-do was 147,274 in 2020, and the elderly population accounts for 19.9%. Among them, 8,154 emergencies occurred in 2018, 8,105 in 2019, and 7,180 in 2020 (Table 1). The transferred elderly patients account for 40% of the transfers.

Table 1: Classification of transferred patients based on year

year	Gender N (%)		
	male	female	unknown
2018 (N=8,154)	4,683(57.4)	3,470(42.6)	1(0)
2019 (N=8,105)	4,628(57.1)	3,477(42.9)	0(0)
2020 (N=7,180)	4,048(56.4)	3,132(43.6)	0(0)

The patients were then classified according to their symptoms. Among all emergency patients, a survey was conducted focusing on patients who were transferred to the hospital and treated in the emergency room, and patients who recovered after arriving at the emergency room and returned home immediately were excluded. Regarding causes for transfer to emergency services, injury was the most common, followed by cerebrovascular, circulatory, or respiratory emergency. The average transfer time was 26 minutes (Table 2).

Table 2: Classification according to symptoms and transfer time to the hospital.

Disease	N	Minimum time (min)	Maximum time (min)	Average time (min)	Standard Deviation
Infectious disease	699	6	94	24.37	10.483
Musculoskeletal system	684	9	82	27.71	10.614
Unclassified disease	2809	7	121	26.3	11.012
Endocrine disease	478	9	83	29.31	11.145
Cerebrovascular system	846	10	95	28	10.486
Eyes, ears	653	8	87	26.77	9.703

Urogenital	1044	6	109	25.57	10.367
Obstetrics and Gynecology	36	10	43	22.17	8.338
Digestive system	1454	8	145	26.08	11.519
Circulatory system	1489	3	148	25.98	10.65
Nervous system	725	4	73	25.57	10.047
Cancer	542	8	86	26.81	9.803
Injury	7167	3	570	28.03	15.826
Mental illness	776	8	252	28.57	15.593
Special inspection	299	10	89	27.94	11.676
Skin system	136	8	96	24.61	11.403
Vascular system	49	12	59	26.31	9.792
Blood disease	94	13	66	26.82	8.92
Respiratory system	1339	8	89	24.89	10.198

Next, we compared and analyzed whether the external environment had an effect on the injured patient's transportation by evaluating the factors causing delay in transfer.

Among the various causes of injury, the number of patients who fell (2,633 persons) was the highest, and this indirectly shows that a large number of elderly patients exist due to an increase in the elderly population (Table 3). Regarding the transport of emergency patients, it was examined whether transport was delayed due to external environmental factors, such as traffic congestion, heavy snow, heavy rain, and requests from guardians. Among them, there was no transport delay due to heavy snow, but traffic congestion, heavy rain, and requests from guardians resulted in significant transport delays (Fig. 1). The analysis values are shown in Table 4. Subsequently, to confirm the patient's treatment time on site, arrival time from the transport vehicle's initial location to the site and arrival time from the patient's initial location to the hospital were examined. Among injured patients, the most common on-site treatment was an electrical accident, which took an average of 36 minutes (Table 5).

Table 3: Classification according to injured patients.

Accidental Injury	Patients (N)	Accidental Injury	Patients (N)
Chemical substance	2	Animal/insect	327
High-temperature body	21	Animal/insect	3
Penetrating wound	6	Water	33
Machine injury	255	Wound	504
Other blunt injuries	404	Sexual assault	1
Others (accident injuries)	309	Laceration	578
Fall to the floor	2633	Heat damage	14
Farm machinery	21	Drowning	3
Choke	6	Stab	35
Fall from a height	353	Electrical accident	9
Flame	48	Overdose	31

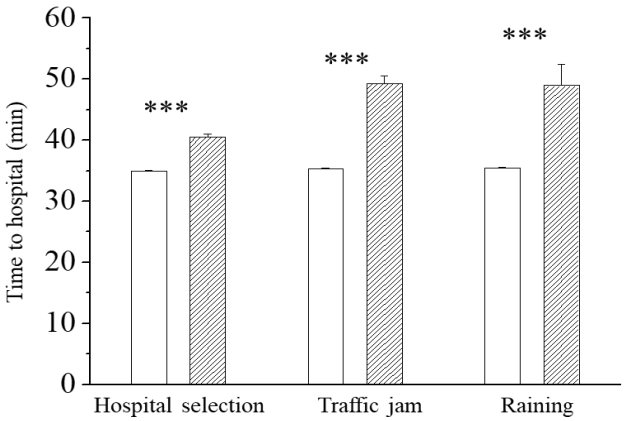

Figure 1: External factors influencing transfer delay. Various factors that delayed patient transfer were investigated. Duplicate factors were excluded and analyzed as a single factor. Hospital selection took 40 minutes, traffic jams took 49 minutes, and rain took 48 minutes on average. *** < 0.001

Table 4: Analysis values of time to hospital

Independ t-test						
External factors	**t**	**df**	**Sig.(2-tailed)**	**Mean Difference**	**95%Confidence interval of the Difference**	
					Lower	**Upper**
Hospital selection	12.963	23434	.000	5.58502	4.74056	6.42948
Traffic Jam	10.840	311.021	.000	13.98584	11.44732	16.52437
Raining	4.555	23434	.000	13.52375	7.70388	19.34361

Table 5: Classification according to injured patients and transfer time to the hospital.

	N	**Minimum time (min)**	**Maximum time (min)**	**Average time (min)**	**Standard Deviation**
Electrical accident					
Time to site	9	00:09	00:43	00:17	00:10
Time to hospital	9	00:24	01:57	00:54	00:31
On-site treatment time	9	00:11	01:14	00:36	00:24
Fall					
Time to site	353	00:06	03:28	00:19	00:15
Time to hospital	353	00:10	03:34	00:39	00:21
On-site treatment time	353	00:01	02:01	00:19	00:13
Thrown off balance					
Time to site	2633	00:01	06:29	00:18	00:16
Time to hospital	2633	00:06	07:04	00:36	00:23
On-site treatment time	2633	00:00	02:26	00:17	00:14

4. Discussion

Through this study, we analyzed the data of emergency patients transferred using the past three years. Our findings suggest that among the environmental factors affecting patient transfer time, traffic congestion had the most influence. The issue of traffic problems has already been raised for a long time. To solve this problem, firefighters have been given the right to hand-sign traffic since 2014. Another option is the Emergency Vehicle Priority Signal System (EVPS) which controls traffic signals so that emergency vehicles can safely reach their destination without stopping in front of traffic lights(Nellore & Hancke, 2016). EVPS was first tested in Uiwang-city in 2017 and has been expanded to 10 metropolitan cities nationwide. The system installation was completed in 2021 in Pocheon-city, which we investigated in 2020; so, the results of this study may be considered to rethink the necessity of this system. Moreover, there are several problems with this system. First, although it is possible for the patient to be transported to the hospital, the system does not apply while going to rescue the patient. For conditions where the patient's golden time is important, prompt treatment is crucial. Second, traffic congestion that will occur after traffic control is a negative factor. From the police's point of view, continuous traffic congestion is a negative position where complaints are constantly raised, and the police must face all the criticism. However, at a time when life is precious, a 21-year bill has been proposed and is pending in the National Assembly. In foreign countries, if you interfere with emergency transfer, you are severely punished, such as with a fine of about 800,000 won in the United States and two months of license suspension in Russia. In Korea, traffic obstruction is punishable by imprisonment for up to 5 years or a fine of up to 30 million won. However, in Korea, despite the law, there are very few instances where a fine has actually been imposed. Although civic awareness is important, heavy penalties are also considered as a way to improvise this scenario.

Further, in the case of electrical accidents among injured patients, it took an average of 37 minutes from arrival at the scene to arrival at the hospital. Compared to other injuries, the on-site treatment took a long time, for which the cause was examined. In the event of an electrical accident, the most important thing to pay attention to when rescuing a patient at the scene is not to come into contact with the patient until the power is completely cut off. Electric shock patients may develop various arrhythmias, such as ventricular fibrillation and asystole, and edema may occur in the soft tissues of the airway, which may result in airway obstruction. Therefore, in patients with electric shock, endotracheal intubation should be performed as early as possible at the site, and, if extensive damage is suspected, a large amount of fluid should be administered to prevent loss of body fluid. In addition, since a fall may occur due to an electric shock, there may be a delay due to on-site treatment, such as having to evaluate the entire body to check for damage (Mostafazadeh et al., 2014; Svendsen et al., 2022; Yigit & Sener, 2022).

In this study, weather conditions were examined to determine whether they affected the transport of emergency patients. Transport delays occurred due to heavy rain, but not due to heavy snow. When the comprehensive climate change monitoring information site was consulted, it was found that the amount of snowfall decreased every year. In 2020, there were 10 snowy days, and snowfall decreased by an average of 10 cm each year for the last three years. Heavy snowfall is not considered a major problem for traffic, and it is believed that this could be due to global warming, as there were 120 snow days in 2017, 100 days in 2018, 40 days in 2019, and 60 days in 2020 (Diffenbaugh et al., 2013; Li et al., 2019; McGowan et al., 2018). In addition to heavy rain and long-distance travel due to the request of guardians affected transport time of emergency patients.

5. Conclusions

Through this study, we investigated the transfer time for each emergency condition, the number of transfers, and the external environmental factors affecting the transfer of patients. The patient's transport time is directly related to the patient's life; therefore, they should be transported as early as possible. In our study, hospital selection, traffic, and transfer delays due to heavy rain had the greatest impact. Currently, two ambulances are dispatched when a cardiac arrest patient occurs. However, in this study showed that trauma patients need the treatment time on-site. Therefore, it seems necessary to investigate in detail about various diseases and traumatic accidents. A patient's transfer delay causes another patient's transfer delay. Among various diseases, trauma causes the most transportation delays. This appears to be due to the on-site treat by paramedics. In addition to this, external environmental factors come into do. In particular, electric shock among trauma patients is an emergency that requires various treat. It is necessary to prepare for these various factors. Hence, it is necessary to secure a transportation route for emergency patient transport in the event of heavy rain, to expand the infrastructure necessary for rapid patient transport such that two or more ambulances are available for electric shock patients, and implement strong legal measures traffic obstruction.

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