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Improving the Response Time of Ambulances Using Global Positioning Satellite System (GPS) in Gaza City in the Gaza Strip

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Abstract

An Emergency Medical Service (EMS) has significant impact on health service provision. Its importance refers to that failure of ambulances to respond to emergency calls within set times may result in loss of life. The purpose of this study is to assess the effect of using a Global Positioning System (GPS) on EMS response time in a district of Gaza City. A digital routable map, as an equivalent system to GPS, was placed in an ambulance of an EMS provider. The system was programmed to select the fastest route to the scene. Over a one-week period, data were collected using one ambulance with the same driver and same navigation team. The ambulance driver was asked to drive to a randomly selected address once without using the GPS equivalent system and another with using it, the response time was recorded every time using a stopwatch. The results confirm that the mean response time of the ambulance with GPS was significantly shorter, 4.7 min. +/-1.5 min (mean +/- SD) compared to the response time without GPS which was 6.05+/- 3.04 min (mean +/- SD). GPS technology can significantly improve EMS response time to the scene of emergencies by as much as 20%.

Keywords: Emergency Medical Service, Ambulance, Ambulance Response Time, Global Positioning System.

1. Introduction

Ambulance services are an integral part of a well-functioning Emergency Medical Service System, (EMS) which is an essential part of any healthcare system. To provide good EMS performance resources are required such as paramedics and vehicles, dispatch centres, medical and non-medical ambulance equipment, and a telecommunication system, allocated according to need. Ambulances and their paramedics provide initial care and emergency transport of ill or injured persons to a suitable healthcare provider centre. They manage and respond to major incidents.

The effectiveness of emergency ambulance services directly relates to patient outcomes. The appropriateness and quality of clinical care delivered by paramedics, and the speed with which a patient reaches a suitable healthcare centre can affect a patient's chances of survival. The response time is measured from the time when a dispatcher receives a call for an ambulance to the time a paramedic reaches the person who is seeking aid (Roth et al., 1984, Cummins et al., 1985, Eisenberg et al., 1990, Spaite et al. 1990).

It is most important to respond as quickly as possible to emergency calls because the sooner an ambulance responds to an emergency call the better the patient's chances of survival (Galea, S et al., 2007, Wilde, E. T., 2009, Pons, and Markovchick, 2002, Blackwell and Kaufman, 2002; Seow E and Lim E, 1993).

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Pell et al., (2001) found that ambulances in the United Kingdom were required to respond to 90% of emergency calls within 14 minutes and that their models suggested that increasing this target to 8 minutes would increase the proportion of potential survivors from 6% to 8%, and responding to 90% of calls within 5 minutes would increase the proportion of survivors to 10-11%. In addition Breen, N. et al., (2000) found that in Ireland 14% of calls took 5 minutes or longer to activate response while 38% of emergencies obtained responses within 9 minutes. Further, it was noted that only 4.5% of emergency calls originating from places greater than 5 miles from the ambulance bases responded within 9 minutes. The current study will discuss this issue for a small area within the Gaza city.

The population of Gaza, like any city in the developing world, lives a critical situation concerning infrastructure, community health, and school health and so on. Gaza City, being the centre of Gaza Strip and occupying a strategic location in the area of Israeli-Palestinian conflict, faces a lot of emergency situations that create problems and cause many complications for the working groups in the field of relief and emergency. The Palestinian Red Crescent Society (PRCS), a national humanitarian organization, is the sole provider of emergency ambulance services in the Gaza strip for a population of 1, 7 million.
(http://www.pcbs.gov.ps/site/881/default.aspx#Population). The Palestine Red Crescent Society (PRCS) was founded in December 1968. Since its establishment it has contributed to the health and welfare of the Palestinian people and others in need in the West Bank and Gaza Strip (Occupied Palestinian Territories OPT) and the Palestinian diaspora. It has about 4,200 employees in OPT, Lebanon, Syria, Egypt and Iraq in addition to its volunteer network of more than 20,000 people. (http://www.palestinercs.org/en/prcs.php). Since 1994 the PRCS has had a mandate from the Palestinian National Authority (PNA) to respond rapidly to requests for help in a medical emergency. At the same time the PRCS is not responsible for non-urgent patient transport, such as when a patient needs to be moved from one hospital to another (inter-hospital transfer).

Emergency situations in Gaza can be classified into two main categories, the first includes emergency situations caused by the military actions which cause a lot of injuries, and these can be handled through the coordination of the Palestinian Red Crescent Society (PRCS) and the International Committee of the Red Cross (ICRC) together with the occupation forces. The other category includes normal emergency situations concerning injury or illness. Currently, emergency operations are handled either through PRC (101) or through Civil Defence (102). It is a simple manual, pre-digital system that is slow by today's standards. In addition, there are different variables to consider, for example, the skills of the dispatchers to determine the exact location of an event as well as the skills of the ambulance driver or Civil Defence car driver in reaching the location of the event in minimal time.

The aim of this study is to focus on emergency ambulance services, examining response time performance using guidance from a digital routable street map based on GPS to improve the ability of EMS drivers to locate their destination and to shorten the ambulance response times in Gaza City in the Gaza Strip in Palestine, i.e. a small city in a developing country. (Ota, F. S. et al., 2001, Gonzalez, Richard P. et al., 2009; Gossage, J. A. et al., 2008). The focus of the study is on the travel interval part of the response time, i.e. the time interval that begins when the ambulance begins travel and ends when the ambulance arrives at the scene (see Figure 1).

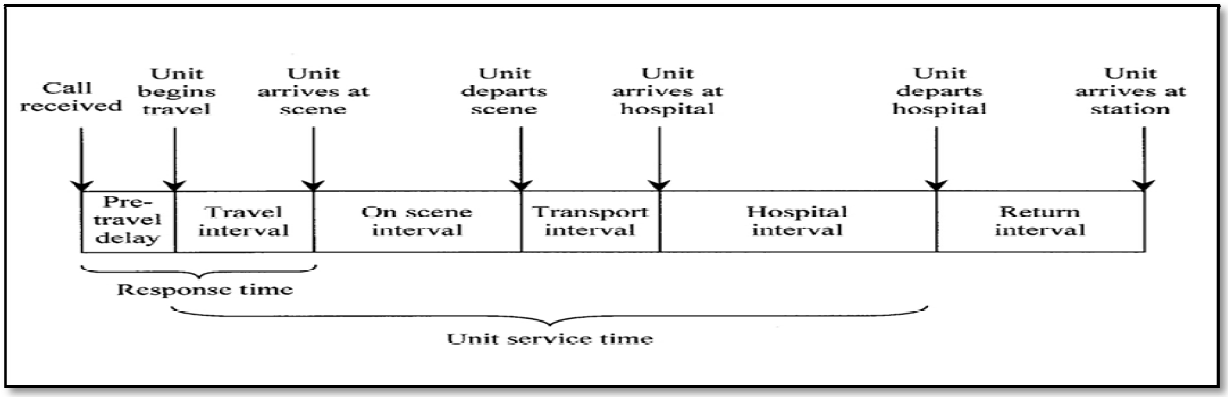

Figure 1: The response time (Altintas, K. H., Bilir, N., 2001)

2. Methods and Study Design

A digital routable map, as an equivalent system to GPS, was placed in an ambulance of an EMS provider. The system was programmed to select the fastest route to the scene (not the shortest). Over a one-week period, data were collected using one ambulance with the same driver and same navigation team. The ambulance driver was asked to drive to a randomly selected address once without using the GPS equivalent system and another with using it, the response time was recorded every time using a stopwatch. The journeys were simulated, i.e. no patients were transported but the drivers were instructed to drive as normal, as though there was a patient.

Northern Remal covers an area of 2.373 km2 with around 35.1358 inhabitants, and Southern Remal Area covers an area of 2.765 km2 with around 24.501 inhabitants. (The data is from the Gaza City municipality, Figure 2).

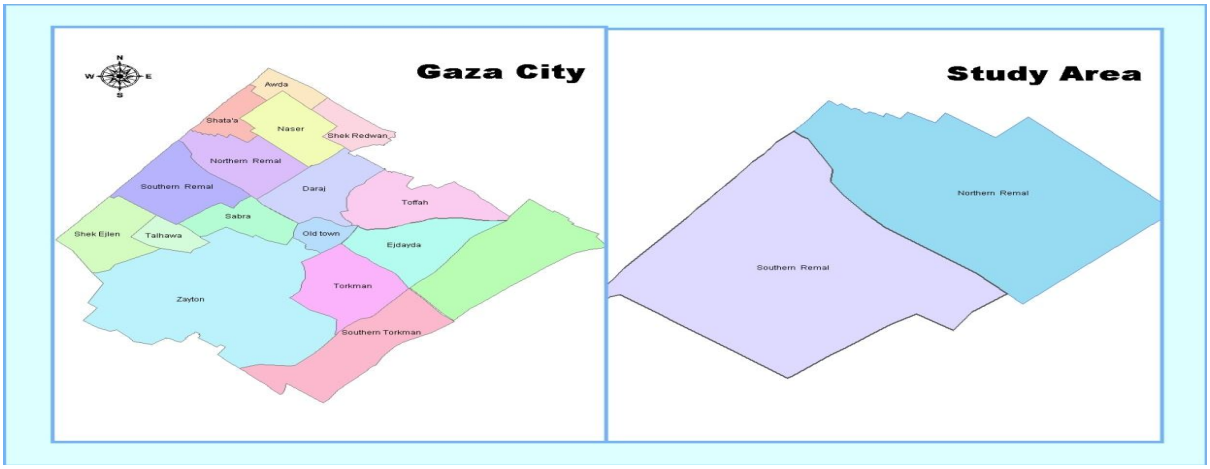

Figure 2: Maps of Gaza City and the study area

Study Limitation (Preconditions)

1. Only one ambulance was used over a period of a week. The driver had more than five years of work experience and he knew the area geographically very well.
2. There was no GPS device available, so an equivalent system was used. This system was a digital routable map of a Gaza-City district running on a laptop.
3. The location for the start was Al-Shifaa Hospital, a central public hospital in Gaza.
4. It was not possible to select another area due to the lack of digital maps with street names.
5. Two minutes were added to the travel interval response time, one minute for the dispatcher and one minute to prepare the team and for entry to the ambulance (Shah et al, 2001).
6. The addresses were randomly selected from the Remal residential district, (currently divided into the districts of Northern Remal and Southern Remal), situated along the coastline 3 kilometres from the city centre.
7. The driver/navigator team was assigned to drive to an address first without GPS. The ambulance driver then returned to the dispatch centre from where he drove to the same address again but this time with the support of GPS. One navigator instructed the ambulance driver as to which route to take. On each occasion the response times were recorded using a stopwatch.
8. The process was simulated no injured or ill person was transported. All journeys took place during the day, i.e. not at night.
9. The travel times from both journeys were recorded and prepared for further analysis.

2.1. Statistics And Data Analysis

The results will be analysed using graphical analysis, statistical quality analysis and design of experiment tests, i.e. hypothesis testing and T-Test. (Mini-tab and SPSS version 19 were used).

3. Results And Discussion

3.1 Results

The response time data recorded without GPS over one week are included in Table 1. While the response time data recorded with GPS over one week are included in Table 2**.**

Table 1: Ambulance response times in minutes over one week without GPS

Nr. of Case / Day	1	2	3	4	5
Saturday	4.41	4.8	3.26	4.59	4.4
Sunday	8.4	5.26	6.14	5.16	4.34
Monday	4.33	6.09	7.57	3.21	5.19
Tuesday	3.55	4.32	4.1	4.5	9.34
Wednesday	7.44	5.07	7.57	10.17	3.12
Thursday	7.56	4.17	3.33	19.3	6.4
Friday	10.29	4	7.33	5.47	8.12

Table 2: Ambulance response time in minutes over one week with the GPS assistance

Day / Nr. of Case	1	2	3	4	5
Saturday	3.3	2.4	3.16	4.4	4.2
Sunday	7.19	4.3	5.57	5.1	4.12
Monday	4.17	3.33	4.34	2.57	4.47
Tuesday	3.45	4.14	3.43	4.5	4.2
Wednesday	6.19	4.37	6.49	6.33	2.52
Thursday	5.15	3.52	3.11	7.26	5.22
Friday	10.08	3.27	7.19	5.13	5.29

Figure 4 shows the comparison of the ambulance response times (ART) with and without GPS. It can be seen that the response times without GPS have a larger variation than those with GPS.

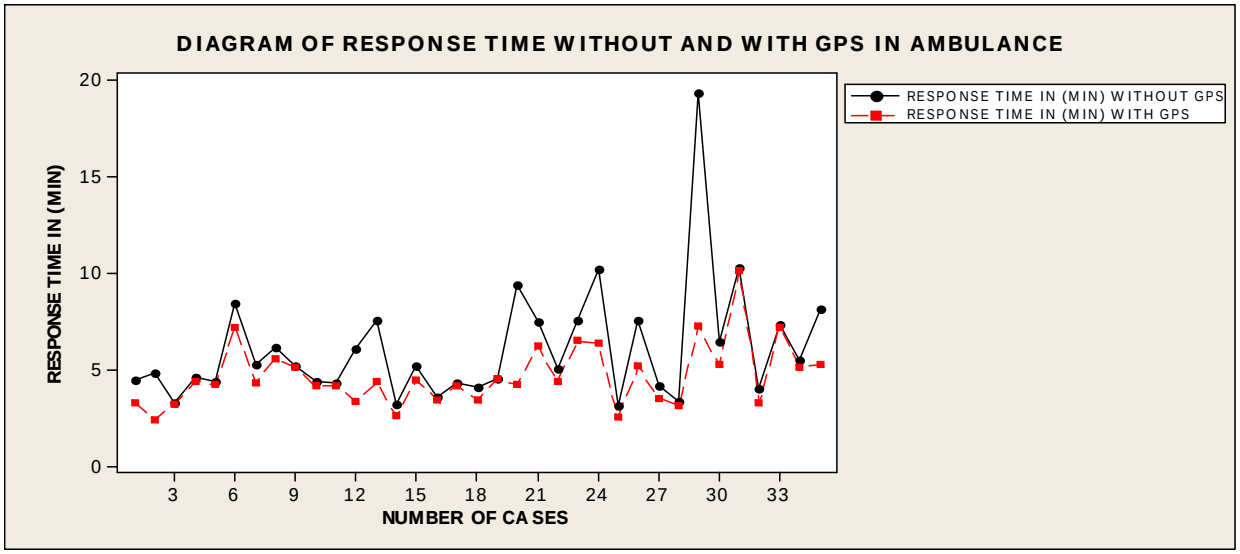

Figure 4: The comparison of the ambulance response times (ART) with and without GPS

Table 3 contains the mean, standard deviation (SD) and the variance (VAR) for both response times. It shows that the value the standard deviation and the variance in the case of using GPS are smaller than the others. Figure 5 and 6 are containing histogram of the response time of ambulance, before and after using GPS.

Table 3: Data analysis before and after using GPS

Parameters	Response Time before using GPS	Response Time after using GPS
Mean	6.0	4.7
SD	3.0	1.5

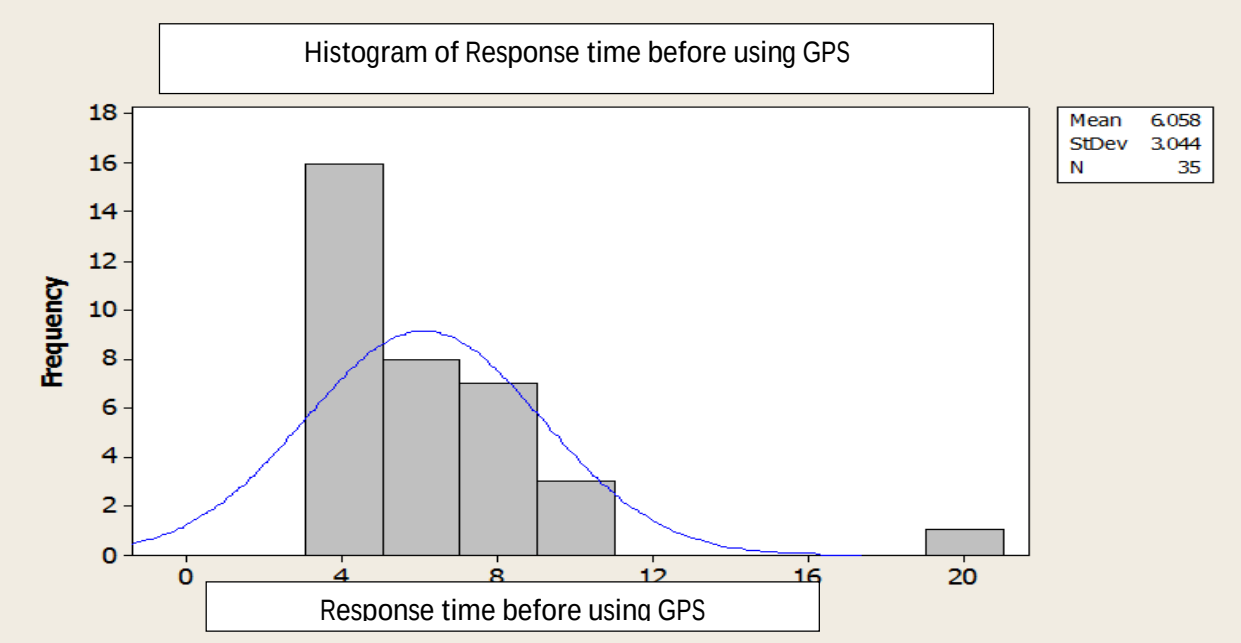

Figure 5: Histogram of ambulance response times without GPS

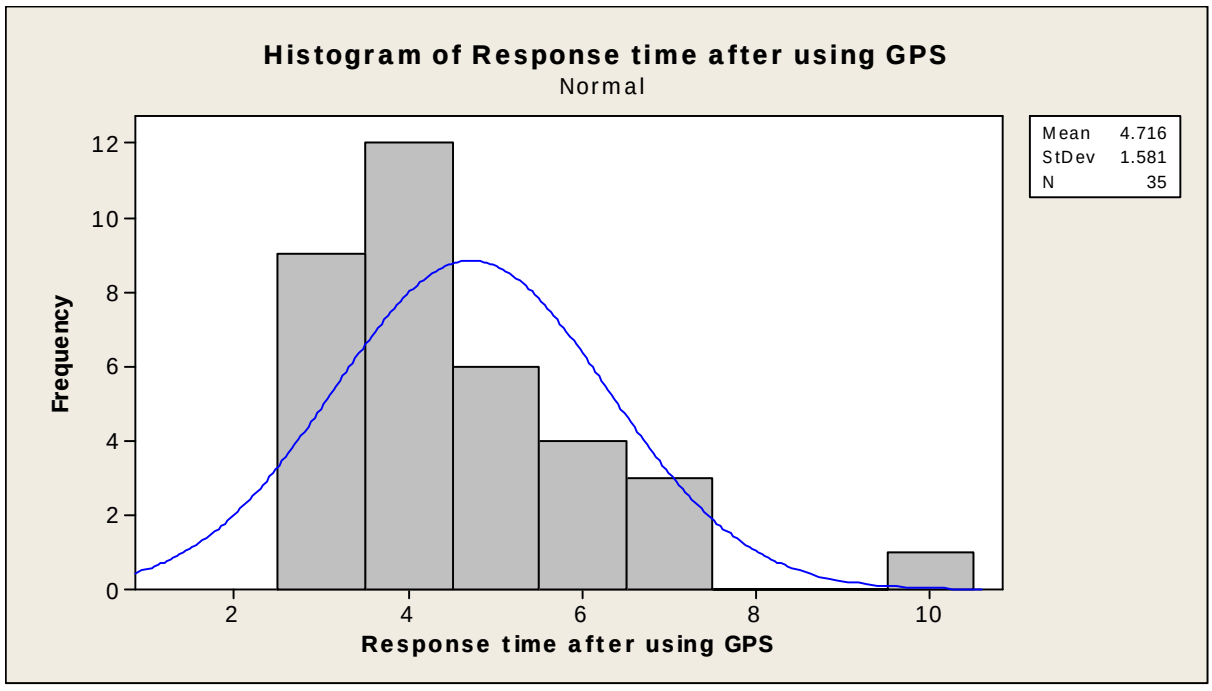

Figure 6: Histogram of ambulance response times with GPS

The recorded data was analysed with statistical quality tools such as control charts and. It can be seen that the process capability with GPS is better than the process without using GPS. Then the process of using GPS has a higher process capability and has less variation and is also the process is in a state of control, as it can be seen in the figures 7 and figure 8.

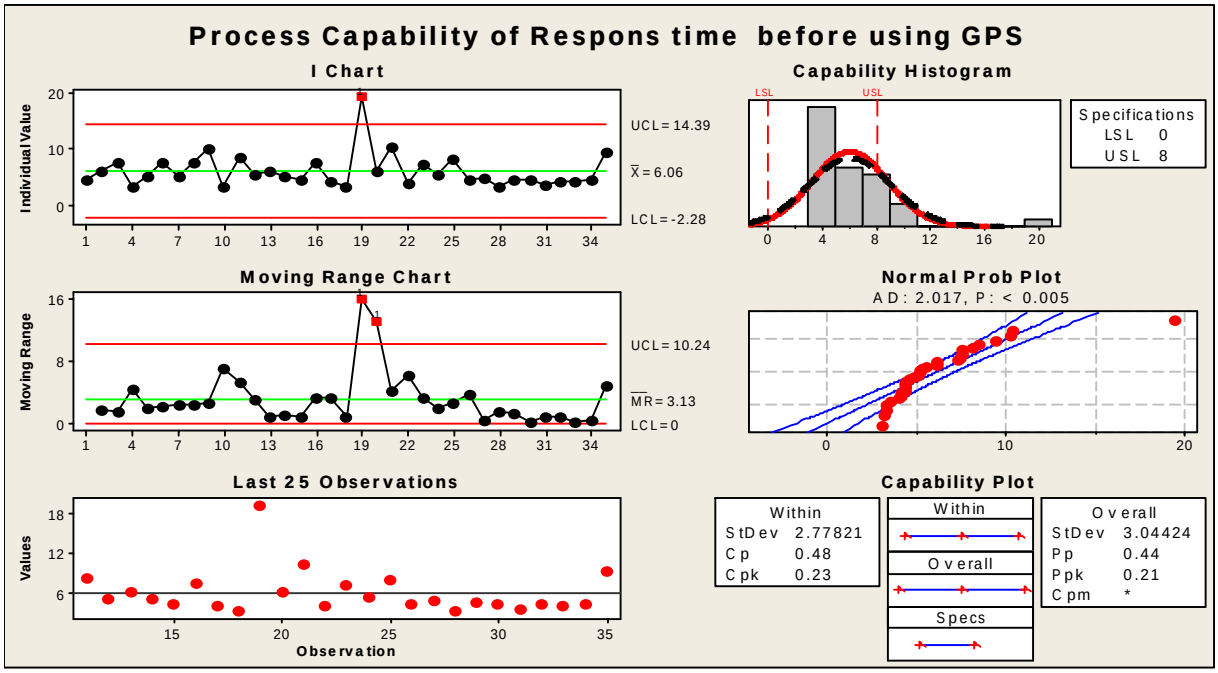

Figure 7: Control charts and process capability of the response time without using the GPS

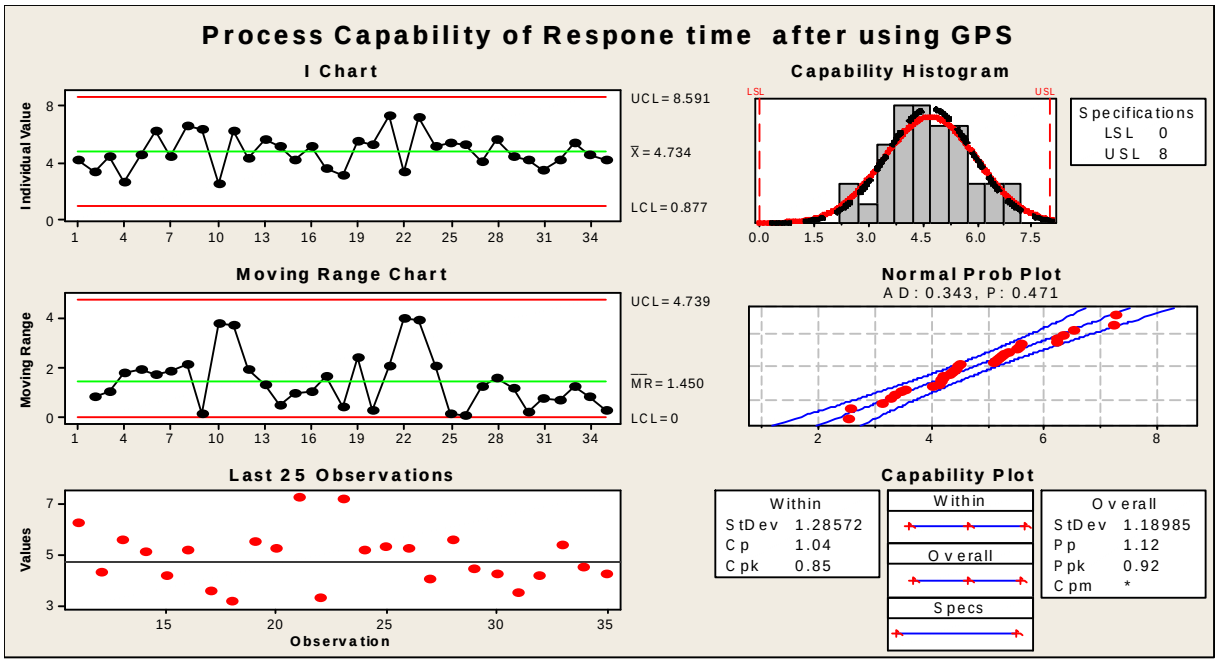

Figure 8: Control charts and process capability of the response time with GP

To find out, if there is a significant difference between the mean of the response time of ambulances with/and without GPS. The null hypothesis follows:

$H_0 : \mu_0 = \mu_1$, and the alternative hypothesis is

$H_1 : \mu_0 > \mu_1$,

(In other words, the null hypothesis is that there is no difference between the mean response time of the ambulance with/and without GPS. The alternative hypothesis is that, the mean response time without GPS is higher than the mean response time with GPS). Using *T* –Test the following results were obtained.

T-Test

Group Statistics

	Method	N	Mean	Std. Deviation	Std. Error Mean
Ambulance response time in minutes over one week	Without GPS	35	6.0657	3.04476	.51466
	With GPS	35	4.6703	1.62528	.27472

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Without	6.0657	35	3.04476	.51466
	With GPS	4.6131	35	1.73865	.29389

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Without With GPS	1.45257	2.26992	.38369	.67283	2.23231	3.786	34	.001

The results show that the null hypothesis should be rejected, then the value of t is = 3.786 which is higher than 1.96 (t value from statistics-table) and the P-value is = 0.001, also less than 0.05 and since the sign of the Test is positive, that means the mean response time of the ambulance without using GPS is significantly greater than the mean response time with using GPS. It means also that the alternative hypothesis should be accepted. In conclusion and according to T-Test, the mean response time with GPS is shorter than the mean response time without GPS.

3.2 Discussion

Comparing the results of the current study with similar published studies, for example the study of Peleg and Pliskin (2004).They found that before using the GIS & GPS model, the mean response times in the Carmel and Lachish districts were 12.3 and 9.2 minutes, respectively, with 34% and 62% of calls responded within 8 minutes. When ambulances were positioned within the modelled polygons, more than 94% of calls met the 8-minute criterion.

In another study published by Gonzalez et al. (2009), the mean EMS response time for motor vehicle crashes (MVCs) was 8.5 minutes without GPS and 7.6 minutes with GPS ($p < 0.0001$). When MVCs were matched for miles travelled, mean EMS response time without GPS was 13.7 minutes versus 9.9 minutes with GPS ($p < 0.001$). Ota et al. (2001) have been discussing this issue in their paper entitled " GPS computer navigators to shorten EMS response and transport times". They found that the GPS team arrived faster in 72% runs. The results showed that the majority EMS providers surveyed noted that the GPS computer navigator is enhancing their ability to locate the destination faster and all EMS providers approved that it would enhance their ability to find a destination in an area in which they were unfamiliar.

4. Conclusion

It has been proved that there is a positive impact of using GPS by shortening the ART of ambulances in Gaza City by about 20 %. With GPS the mean response time was 4.7± 1.5 minutes and without GPS it was 6.05± 3.04 minutes. Those results depend on the collected, recorded and analysed data of ambulance response time with and without GPS in the ambulance. Furthermore the T-test has also proved the hypothesis. In conclusion it can be confirmed, that GPS system may be a valuable tool in reducing ambulance response times.

5. Recommendations

1. Ambulances in Gaza should be equipped with a GPS guidance system.
2. Funding should be developed to enhance infrastructure and technology for EMS communication systems including access to the Internet and enhanced links to telemedicine.
3. The government should be encouraged to support and facilitate efforts to develop pre-hospital EMS data collection to analyse opportunities for training and to identify the best practices and to provide opportunities for quality improvement.
4. Community education in the appropriate use of the EMS system as well as emergency medical dispatcher training should be developed.
5. Civil defence vehicles and police cars should also be equipped with GPS.

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