

**A CROSS SECTIONAL STUDY OF AMBULANCE RESPONSE  
TIME USING AMBULANCE VEHICLE LOCATOR AND GLOBAL  
INTEGRATING SYSTEM (AVL-GIS), AND THE FACTORS  
CONTRIBUTING TO DELAYED AMBULANCE RESPONSE TIME  
AT HOSPITAL UNIVERSITI SAINS MALAYSIA**

**by**

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## **LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS**

AMO	Assistant Medical Officer
APM	Angkatan Pertahan Malaysia (Malaysian Civil Defense)
AVL-GIS	Ambulance Vehicle Locator And Global Integrating System
CI	Confidence interval
EMD	Emergency Medical Dispatcher
EMS	Emergency Medical Services
HUSM	Hospital Universiti Sains Malaysia
HRPZ	Hospital Raja Perempuan Zainab II
MECC	Medical Emergency Call Centre
OR	Odds ratio
SD	Standard deviation



**KAJIAN BERSILANG BERKENAAN TEMPOH RESPON AMBULANS  
MENGUNAKAN PENGESAN KENDERAAN AMBULANS DAN SISTEM  
INTEGRASI GLOBAL (AVL-GIS), DAN FAKTOR-FAKTOR YANG  
MENYUMBANG KEPADA KELEWATAN TEMPOH RESPON AMBULANS  
DI HOSPITAL UNIVERSITI SAINS MALAYSIA**

**ABSTRAK**

**Pengenalan** Kajian ini bertujuan untuk menentukan tempoh respon ambulans di daerah Kubang Kerian, Kelantan, Malaysia menggunakan peranti Pengesan Kenderaan Ambulans dan Sistem Integrasi Global (AVL-GIS) dan faktor-faktor yang berkaitan dengan kelewatan tempoh respon. **Kaedah** Merupakan prospektif selama 6 bulan, kajian bersilang yang dijalankan di Jabatan Kecemasan dan Trauma, Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan, Malaysia. Faktor-faktor yang mungkin dikenalpasti telah menyebabkan kelewatan tempoh respon ambulans daripada literatur terdahulu terkandung dalam kajian ini. Semua kes pra-hospital daripada September 2017 hingga Februari 2018 yang dirawat oleh ambulans yang dilengkapi dengan AVL-GIS terkandung dalam kajian ini. Data diperolehi daripada borang-borang standard Proforma pra-hospital dan diekstrak daripada AVL-GIS menggunakan perisian GPS. Ujian regresi logistik yang mudah dan pelbagai telah digunakan untuk menentukan faktor-faktor berkaitan dengan kelewatan tempoh respon. **Keputusan** Min masa respon ambulans adalah 12 minit. Sebanyak 505 kes telah dimasukkan dalam kajian ini, di mana 75% telah diiktiraf sebagai kes-kes terlewat dan 25% sebagai tidak terlewat. Faktor dalaman yang berkaitan dengan kelewatan tempoh respon dikenalpasti merupakan tempoh panggilan (OR:1.67; 95% CI: 1.37, 2.05) dan jenis pemanggil, di mana panggilan daripada orang awam mempunyai kelewatan tempoh respon yang lebih tinggi berbanding dengan

panggilan yang diterima daripada Pusat Panggilan Kecemasan Perubatan (OR=0.38, 95% CI: 0.24, 0.59) dan sektor kecemasan lain (OR=0.16, 95% CI: 0.07, 0.34). Bagi faktor luaran, tempoh peruntukan pasukan (OR=1.57, 95% CI:1.32, 1.85), tempoh perjalanan (OR=3.7, 95% CI: 2.82,4.85) dan keadaan trafik (OR 0.47, 95% CI: 0.25, 0.90) adalah sangat berkaitan dengan kelewatan tempoh respon ambulans. **Kesimpulan** Kajian ini memutuskan bahawa jenis pemanggil, tempoh panggilan, tempoh peruntukan pasukan, tempoh perjalanan dan keadaan trafik didapati signifikan dalam mempengaruhi tempoh respon ambulans. Penilaian terhadap setiap komponen yang menyumbang kepada kelewatan tempoh respon ambulans diperlukan untuk intervensi bagi penambahbaikan penjagaan pra-hospital pada masa hadapan.

*Kata Kunci:* tempoh respon, ambulans, perkhidmatan perubatan kecemasan, pra-hospital, AVL-GIS

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AMBULANCE RESPONSE TIME AT HOSPITAL UNIVERSITI SAINS  
MALAYSIA**

**ABSTRACT**

**Introduction** This study aims to determine ambulance response time in Kubang Kerian district, Kelantan, Malaysia using Ambulance Vehicle Locator and Global Integrating System (AVL-GIS) device and the factors associated with delayed response time.

**Methods** This was a 6-months prospective, cross-sectional study conducted at Emergency and Trauma Department, Hospital Universiti Sains Malaysia (HUSM) in Kubang Kerian, Kelantan, Malaysia. The possible factors identified to have caused delayed ambulance response time from previous literatures were included in this study. All prehospital cases from September 2017 until February 2018 attended to by AVL-GIS installed ambulances were included in this study. Data were obtained from the standardized prehospital Proforma forms and extracted from AVL-GIS using a GPS software. Simple and multiple logistic regression tests were used to determine the factors associated to delayed response time.

**Results** The mean ambulance response time was 12 minutes. A total of 505 cases were included in this study in which 75% was recognized as delayed cases and 25% cases as non-delayed. Internal factors associated with delayed response time were found to be call duration (OR:1.67; 95% CI: 1.37, 2.05) and caller type in which calls from the public had higher odd of delayed response time as compared to calls received from Medical Emergency Call Centre (OR=0.38, 95% CI: 0.24, 0.59) and other emergency sectors (OR=0.16, 95% CI: 0.07, 0.34). For external factors, team

allocation time (OR=1.57, 95% CI:1.32, 1.85), travelling time (OR=3.7, 95% CI: 2.82,4.85) and traffic condition (OR 0.47, 95% CI: 0.25, 0.90) were significantly associated with delayed ambulance response time. **Conclusion** This study concluded that type of caller, call duration, team allocation time, travelling time and traffic condition were found to be significant in affecting ambulance response time. Evaluation of each component contributing to delayed ambulance response time is needed for intervention to improve prehospital care in the future.

*Keywords:* response time, ambulance, emergency medical service, prehospital, AVL-GIS

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

#### *Ambulance Response Time*

One of the components in determine quality indicator of prehospital care is ambulance response time. The shorter duration of ambulance arrival to emergency scene correlate with good quality of service and patient satisfaction in other to deliver primary care to the patient before sending them for definitive care in hospital.

Definition of ambulance response time varies in few literatures done previously. It is included as one component of total prehospital care time which is define as ambulance response time plus on scene interval plus ambulance transport time (Carr et al,2016). Ambulance response time, it is defined as time from receiving call in ambulance base until ambulance arrives to the scene (Shah, 2005) but it also can be prolonged if contact time to patient is delayed (Campbell et al, 1993).

Previous study conducted in Hospital Universiti Sains Malaysia in 2008 to determine the ambulance response time after initiation of Emergency Medical Dispatcher program. From this study, its revealed that ambulance response time is around 15 minutes which is far from international standard 8 minutes as benchmark for good ambulance service. This international standard of 8 minutes was based on study by Eisenberg et al in 1979 which concluded that survival of out of hospital cardiac arrest decreased significantly if definitive treatment (which define as defibrillation and intubation in this case) was not initiated within 8 minutes.

### *Factors Delayed Ambulance Response Time*

Few literatures published had identified similar factor that delayed ambulance response such as weather, heavy traffic and geographical factor. Heavy weather had significant association to cause delayed ambulance response time (Lam et al, 2015) in which it will affect the view from ambulance driver and the road condition during that time. The geographical factor which will contribute in the prolonged the travelling time such as geographical distribution of incident place for example high rise building or in remote area (Breen at al, 2000).

### *Ambulance Vehicle Locator and Global Integrating System (AVL-GIS)*

Ambulance Vehicle Location and Global Integration System (AVL-GIS) is use in the ambulance to spot mapped the location of emergency scene and estimating the arrival time to destination while giving the option of fastest route which will assists in reducing ambulance response time. In Malaysia, there is only few ambulances that installed with this system and thus no local study available in the literature that assessing the response time using AVL-GIS. However, in one study at Gaza they found that mean ambulance response time was significantly improved with ambulance installed with GIS (Abed, 2015).

## **1.2 Justification of Study**

Ambulance response time for prehospital services HUSM 10 years ago is average of 15 minutes and this is from previous study conducted in 2008 (Shah et al, 2008). This study is to determine the current ambulance response time after few interventions had been made for past years. The implementation of new technology installed in the ambulance, AVL-GIS is use in the method of study for recording of exact response time

of the ambulance. Ambulance response time which are including call processing time, team allocation time and travelling time and each component of time will be assessed to determine the factor that can contribute to delayed response time. The association of these factors to delayed ambulance response time is important for improvement of prehospital services and care.

## **CHAPTER 2**

### **STUDY PROTOCOL**

#### **2.1 Introduction**

One of the components in determine quality indicator of prehospital care is ambulance response time. The shorter duration of ambulance arrival to emergency scene correlate with good quality of service and patient satisfaction in other to deliver primary care to the patient before sending them for definitive care in hospital.

Definition of ambulance response time varies in few literatures done previously. It is included as one component of total prehospital care time which is define as ambulance response time plus on scene interval plus ambulance transport time (Carr et al,2016). In response time, it is defined as time from receiving call in ambulance base until ambulance arrives to the scene (Shah, 2005) but it also can be prolonged if contact time to patient is delayed (Campbell et al, 1993).

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installed with this system and thus no local study available in the literature that assessing the response time using AVL-GIS. However, in one study at Gaza they found that mean ambulance response time was significantly improved with ambulance installed with GIS (Abed, 2015).

## **2.2 Problem statement and Study Rationale**

Ambulance response time for prehospital services HUSM 10 years ago is average of 15 minutes and this is from previous study conducted in 2008 (Shah et al, 2008). This study is to determine the current ambulance response time after few interventions had been made for past years. The implementation of new technology installed in the ambulance, AVL-GIS is use in the method of study for recording of exact response time of the ambulance. Ambulance response time which are including call processing time, team allocation time and travelling time and each component of time will be assessed to determine the factor that can contribute to delayed response time. The association of these factors to delayed ambulance response time is important for improvement of prehospital services and care.

## **2.3 Literature review**

A systematic review level III evidence articles by Harmsen et al (2015) on total pre hospital time on outcome of trauma patients from inception until 19<sup>th</sup> May 2014. From these 20 articles, 6 studies recorded that ambulance response time influence on mortality and 2 studies unable to find any significant of activation time and mortality in adult trauma patient. Meanwhile the on scene interval is the most reported to have significance difference in mortality outcome which is 10 studies in total.

Carr et al (2016) reported in their meta analysis on prehospital care time for trauma over 30 years period studies were included. From the analysis, the mean activation time recorded from total 49 articles within United States are 1.4 minutes (urban area), 1.4 minutes (suburban area) and 2.89 minutes (rural area). Meanwhile the mean ambulance response time recorded as 5.28 minutes (urban area), 5.23 minutes (suburban area) and 7.86 minutes (rural area). Although the geographical factor can affect the response time in United States but it still achieves the 8 minutes standard response time

Study for determinants of ambulance response time was conducted based on EMS database from Women and Children Hospital in Likas, Sabah by Chin et al from January 2015 until February 2016. Multiple regression is used to identify significant factors to affect ambulance response time. From this study, average response time is 16.42 minutes and the significant variable (factor) that affect response time are distance ( $p=0.028$ ), peak hours due to congested traffic( $p=0.020$ ), type of emergency case in which medical case ( $p=0.046$ ) more significant than trauma case.

Similar method done in a study by Do et al (2013) in which they found that high call volume predicted to have prolonged ambulance response time (at 90<sup>th</sup> and 50<sup>th</sup> percentile ambulance response time, each additional call at last one hour increase ambulance response time to 1.56 minutes and 0.96minutes). Meanwhile patient related factor not significantly increase ambulance response time.

In Ireland, a national census of ambulance response time emergency calls by Breen et al (2000) stated that factors identified that influenced ambulance response time are geographical distribution of ambulance stations, availability of crewed vehicles to respond, distance and traveling conditions and also use of emergency ambulances for routine care.

Interval from ambulance arrival to scene until contact with patient is quite

significant in contributing to total ambulance response time. This can be approved by Campbell et al, (1993) in his study that stated vertical barrier will impede the movement of paramedic to patient and prolonged the time interval. The potential barriers that affect ambulance response time are identified such as patient extrication, police securing site, physical barriers (doors, stairs, elevator), bystander interference and bad weather condition. The result shows that there is significant difference in median interval time arrival to patient contact in group with barrier (2.29 mins) and without barrier (0.82mins).

Similar study by Morrison et al (2005) which measuring the patient access time interval in population at high rise building. In this study, 2 group were identified: patient who lives 3 storey and below from the ground and patient who lives 3 storey and above from the ground. They found out that patient contact interval is 23.5% from total response time in first group and 32.2% from total response time in second group. The most frequently encountered barriers to access in this study included security code entry requirements, lack of directional signs, and inability to fit the stretcher into the elevator.

Another study in Singapore was published in 2015 by Lam et al to determine the factors that affecting ambulance response time in trauma cases. From 2 years data collected between 1 January 2011 until 31 December 2012 shows that traffic, weather and place of incident were found to be significant in affecting ambulance response time. Heavy traffic has the largest odd ratio of 12.98 ( 95% CI : 10.66-15.79) followed by heavy rain weather 1.58 ( 95% CI :1.26-1.97) and place of incident 1.32 ( 95% CI : 1.2-1.45).

Study on predicted versus actual arrival time of ambulance to respective emergency department using AVL-GIS conducted by McMeekin et al in 2014 at northeast England. Predicted arrival time is time estimated by GIS and actual time is time recorded when

the ambulance reaches the destination. Mean prediction difference between this two time is calculated between urban, suburban and rural area which shows that urban area is over prediction time while other 2 area shows under prediction time. This suggests that the urban road network give more advantage to ambulance path. Apart from that, they also observed arrival time was under prediction during busier traffic time but over prediction outside that hours. Similar result found when looking at seasonal months at initial quarter of year due to poorest seasonal road condition.

## **2.4 Research Questions**

1. What is the current ambulance response time?
2. What are the factors contribute to delayed ambulance response time?

## **2.5 Objectives**

### **2.5.1 General Objective**

To determine ambulance response time using exact location finder (AVL-GIS)

### **2.5.2 Specific Objectives**

1. To determine the association between internal factors with delayed ambulance response time
2. To determine the association between external factors with delayed ambulance response time
3. To determine the association between internal and external factors towards delayed ambulance response time

### **2.5.3 Research Null Hypothesis**

1. There is no association between internal factors with delayed ambulance response time
2. There is no association between external factors with delayed ambulance response time
3. There is no association between internal and external factors with delayed ambulance response time

## **2.6 Research Methodology**

### **2.6.1 Study Design and Duration**

This is a prospective cross sectional study for 6 months duration

### **2.6.2 Study Population**

Reference population: All emergency ambulance calls in Kubang Kerian district

Source population: All emergency ambulance call in Emergency Department, HUSM.

### **2.6.3 Subject Randomization and Recruitment**

No sampling method is applied. All emergency call is included in this study

### **2.6.4 Study Setting**

This study will be conducted in Emergency Department, Hospital Universiti Sains Malaysia (HUSM). The study period is from September 2017 until February 2018.

### **2.6.5 Subject Criteria**

#### Inclusion criteria

1. All emergency ambulance calls within study period of September 2017 to February 2018 are included in the study.
2. All staff who worked in prehospital care setting, Emergency Department HUSM within the study period and consented to participate in this study will be included.

#### Exclusion criteria

1. All 'Borang Sela Masa Tindakbalas Ambulans' with missing data will be excluded from the study.
2. Staff who refused or not consented to participate in this study.
3. Staff who withdraw themselves throughout the study period.

### 2.6.6 Sample Size Estimation

Sample size calculation is based on Peduzzi et al (1996), sample size estimation are made based on objective of this study and number of event per variable (EPV) that will be included in analysis table

Objective 1: Association between internal factors and delayed ambulance response time

6 Internal factors

8 variables (including dummy)

Event per variable (EPV) = 10 and more

8 variable x 10 = 80 case/control (whichever lower)

Delayed – case , non delayed -control

Based on recent data in HUSM, control subject is lower than case (20%)

$N = 80/0.2 = 400$

Objective 2: Association between external factors and delayed ambulance response time

12 external factors

16 variables (including dummy)

Event per variable (EPV) = 10 and more

16 variable x 10 = 160 case/control (whichever lower)

Delayed = case, non delayed =control

$N = 160/0.2 = 800$

Objective 3: Association between internal and external factors with delayed ambulance response time

6 internal + 12 external factors

8 variables + 16 variables

24 variables x 10 = 240 case/control (whichever lower)

$N = 240 / 0.2 = 1200$

In HUSM, the range of ambulance call per shift is about 2 calls per shift and in a month about 110 to 120 case per month. For this study, we took 800 as our sample size as it closer to real number of cases in 6 months duration.

### **2.6.7 Operational Definition**

1. Ambulance response time: measured from the time when a dispatcher receives a call for an ambulance to the time a paramedic arrives to the scene (Carr et al, 2016).

- a) Call processing time: duration of the conversation between emergency caller and call taker at ambulance base (Ambulance Call Centre HUSM)
- b) Team allocation time: duration of preparation team members and equipment.
- c) Ambulance dispatch time: time when ambulance depart from the base
- d) Traveling time: duration taken from ambulance depart and reach the scene
- e) Arrival time: Ambulance reach the scene of emergency
- f) Patient contact time: exact time paramedic reaches and contact with patient