Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 4, February : 2024

APPLICATION OF MODIFIED SINGLE MINUTE EXCHANGE OF DIE FOR THE REDUCTION OF AMBULANCE RESPONSE TIME

Mukesh Shyamkant Desai, Department of Mechanical Engineering, OP Jindal University Raigarh, 496109, Chhattisgarh, India. mukeshsdesai@gmail.com
A. M. Rawani, Former Director, National Institute of Technology, Raipur, 492010, Chhattisgarh, India.amrawani@rediffmail.com
M. I. M. Loya, Former General Manager, Department of Telecommunications and Emerging Technologies, Navtech Pvt. Ltd. Singapore.imloya@gmail.com
Ivan Carillo, Consultant, Lean and Operations Management Rome, Italy. carillo.iv@gmail.com

Abstract
Ambulance Response Time (ART) is the time taken by the ambulance to reach the scene when a person called for it, in an emergency medical situation. This study aims to apply the Modified Single Minute Exchange of Die (MSMED) to reduce ambulance response time at three selected hospitals in Chhattisgarh, India. For this study, a total of 200 emergency calls are taken into consideration. The primary data was collected, with the help of interview techniques and actual observations by attending the 15 emergency callswith an ambulance crew. For this study, a questionnaire is developed to assess the desirability and feasibilityof each recommendation on a five-point scale. After the implementation of the modified SMED, ART has been reduced in a range of 15.22% to 52.55% indicating that the modified SMED is a suitable methodologyfor the reduction of ambulance response time.
Keywords: Ambulance, Ambulance Response Time, Emergency Medical Services, Single Minute Exchange of Die, Modified Single Minute Exchange of Die, Reduction.

1. Introduction

Ambulance response plays a very important role in any emergency medical situation. Ambulance response time is the key performance indicator of EMS. Delay in ART is one of the major causes of death and disability in the world. The utilization of ambulance services in response to emergency medical cases has been an integral part of healthcare service delivery for a long time in most parts of the World. ART is categorized as short if it is less than 4 minutes; intermediate if it is between 4 to 8 minutes and longerif it is more than 8 minutes. Several studies about the EMS system have investigated the mean of ART in different countries as Mexico 4.5 minutes, the U.K. 11.8 minutes, Canada 9.8 minutes, U.S.A.10 minutes, South Korea 6.8 minutes, Japan 6 minutes, Singapore 10.2 minutes, Thailand 11.8 minutes, and India 18 minutes [1]. Thus, extensive research and development are required in the field of EMS for the reduction of ambulance response time.

1.1. Ambulance Response Time (ART)

ART is defined as the time interval between “ambulance dispatch” and “arrival at the incident location”. “Ambulance dispatch” is defined as the event when the ambulance leaves its base station whereas “arrival at the incident location” is defined as the event when the ambulance arrives on the scene. This definition of ART is one of the key performance indicators used by Singapore’s national EMS provider [2;3;4]. The average turnaround time for each incident call is defined as the time interval from the ambulance dispatch event to the handover of the patient to the hospital’s ED [3;4;5].

1.2. Background of Single Minute Exchange of Die (SMED)

Single Minute Exchange of Die was developed by Shigeo Shingo in Japan in the year 1950 at the time of a die change process in Toyo Kogyo's Mazda plant. The basic aim of SMED is to reduce setup time/change over time by identifying different activities involved during the setup change [6]. ‘Single minute’ does not mean that all setup or changeover activities should be completed in only one minute, but that they should take less than 10 minutes, in other words, ‘single-digit minute’ [7].
SMED consists of two types of activities i.e. internal and external activities. Internal activities are those

activities that are performed 'when the machine is switched off' condition. For example, attach and remove die, jigs and fixture, work holding, and tool holding devices. External activities are those activities that are performed 'when the machine is in running condition'. For example, material transfer for machining, preparation of setup trolley for the setup change, transfer of jig/fixture, work holding devices, and tool holding devices which are necessary for setup change or change over operations [8]. The setup operation is defined as the post-adjustment that is performed once before and once after each lot [9].

1.3. Modified Single Minute Exchange of Die (MSMED)

The modified Single Minute Exchange of Die methodology is versatile, unique, and economical, so it may be applied at various hospitals and NGOs for the reduction of ART. If implemented, it will reduce ambulance response time and will help to save the lives of many people. The events relevant to ART are illustrated in the Figure 1.

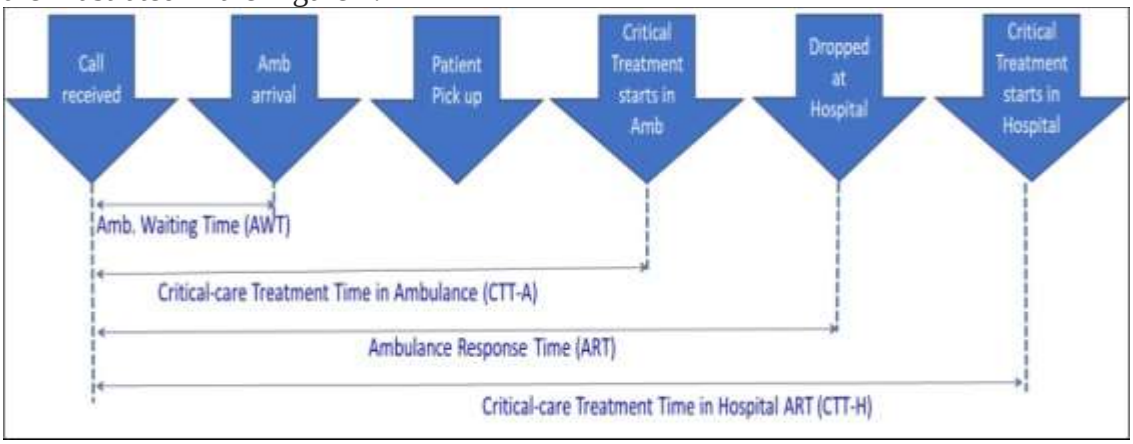

Figure 1: ART Terms

The time interval in the context of ART and are discussed below.

- ART Terms:

- Ambulance Waiting Time (AWT): Time between receiving the call to the arrival of the ambulance at the pickup site.
- Ambulance Response Time (ART): Time between receiving the call to dropping the patient at a hospital.
- Critical Treatment Time in Ambulance (CTT-A): Time between receiving the call to providing in Ambulance Critical Treatment to a patient.

e.g.: For heart cases administrating administers aspirin or Sorbitrate.

- Critical Treatment Time in Hospital (CTT-H): Time between receiving the call to providing Hospital Critical Treatment to a Patient.

e.g.: For an accident case before the Patient reaches the hospital, an ambulance EMT reported the case of blood loss, blood group, head injury, consequently hospital is ready to receive the patient with the right blood group, neurosurgeon and OT is ready for the case. Without this advance reporting, critical treatment would have started with a delay. The delayed saving is a contribution of ART.

2. Research Methodology

To achieve the objective of the study more than one data collection technique and analysis procedure isapplied. The study is divided into two parts namely implementation of modified SMED for the reduction of ART at three selected hospitals in Chhattisgarh, India, and validated the modified SMED. The research methodology for each part is briefly described here and as
shown in Table 1.

Table 1: Research Methodology

Sl. No	Part	Methodology
1	Part 1: Implementation of the Modified SMED i.e. To apply the modified SMED for reducing Ambulance Response Time at selected hospitals in Chhattisgarh.	Data: • 30 Interviews • Time log for 200 calls of 108 service • Time study and field observations by attending 15 emergency calls with the ambulance crew. • Three Brainstorming sessions with a total 34 participants from three selected hospitals of Chhattisgarh. Method and Tools: • Modified SMED • Time analysis • Quantitative analysis
2	Part 2: Validate the modified SMED	Data: • Questionnaire Survey of 30 respondents from threeselected hospitals Method and Tools: • Desirability and Feasibility study

For applying the modified SMED methodology, first, the prevailing process of ambulance service is studied. For this, the primary data is collected, with the help of actual observations by attending the emergency calls with the ambulance crew. During visits, the researcher noted the procedure of ambulance services, the sequence of activities of ambulance services, and the time required for each activity with the help of a stopwatch, and on the basis of collected data internal and external activities are distinguished. A tentative proposal for the conversion of internal activities into external activities is prepared. On the basis of this tentative proposal developed, brainstorming sessions were organized with three selected designated hospitals; possible internal activities that can be converted into external activities are identified. On the basis of the findings, improvement is suggested to reduce the ambulance response time. To validate the modified SMED Methodology, a questionnaire is developed to assess the desirability and feasibility of each recommendation on a five-point scale. For this, three more hospitals in Chhattisgarh, India have been selected on the basis of the convenience sampling method. From the selected hospitals, data are collected from 30 respondents. Analysis of the desirability-feasibility study validated the modified SMED.

3. Implementation of Modified SMED Methodology

To implement the modified SMED, data is collected by means of (a) interviews, (b) call data, and (c) time study of call attended. Identification, separation, and conversion of internal activities into external activities are done. Brainstorming sessions were organized. Based on recommendations, ambulance response time is reduced.

3.1. 108 Ambulance Services: The 108 is the toll-free number for ambulance services in India which provide free ambulance, fire, and Police services 24x7 to people in emergency situations. It is operated by GVK EMRI – Emergency Management and Research Institute were established in April 2005. Currently, it operates in 18 states of India. The role of 108 services is to pick up the patient, provide first aid inside the ambulance if needed, and transport the patient to designated public or private

hospitals as per requirement. For applying the modified SMED methodology, first, the prevailing process of ambulance service is studied.For this purpose, 30 interviews were organized to collect the primary data from the associated hospitals andstaff of 108 services. Hospitals selected for this study are Ramkrishna Care Hospital Raipur, M. M. I. Narayana Hospital Raipur, and Jindal Fortis Hospital Raigarh Chhattisgarh, India. The profiles of the respondents are tabulated in table 2.

Table 2: Respondents Profile for Interviews

Category	Hospitals/ Association	No of Respondents
Doctors'	1. Ramkrishna Care Hospital Raipur. 2. MMI Narayana Hospital Raipur. 3. Jindal Forties, Hospital Raigarh. 4. Primary Health Centre, Tamnar Dist. Raigarh.	10
Emergency Medical Technician (EMT)	1. Ramkrishna Care Hospital Raipur. 2. MMI Narayana Hospital Raipur. 3. 108 ambulance service Raigarh.	6
Driver/Pilot	1. Ramkrishna Care Hospital Raipur. 2. MMI Narayana Hospital Raipur. 3. 108 ambulance service Raigarh.	6
Patient/ caller	1. Ramkrishna Care Hospital Raipur. 2. MMI Narayana Hospital Raipur.	4
Manager on Duty (MoD)	1. Ramkrishna Care Hospital Raipur. 2. MMI Narayana Hospital Raipur. 3. 108 ambulance service Raigarh.	4
	Total	30

Subsequently, primary data is collected from the field with the help of actual observations by attending emergency calls with the ambulance crew. A total of 15 emergency calls were attended by the ambulance crew, for different categories of cases associated with different hospitals in Chhattisgarh. While attending these calls the researcher noted the procedure of ambulance services, the sequence of activities of ambulanceservices, and the time required for each activity with the help of a stopwatch is noted. The call details are tabulated in table 3.

Table 3: Call Log Profile

Nature of calls	No of calls attended
Body Pain	2
Fits	1
General Medicine	3
Heart	2
Labor Pain	2
Not Shift	1
Poison	1
Road Traffic Accident	3
Total	15

Thereafter, the data collected above were subjected to the modified SMED for ART. This includes time analysis and quantitative analysis. First, a tentative proposal for the conversion of internal activities into external activities is prepared. Then, three brainstorming sessions were organized with three selected designated hospitals, in Chhattisgarh, India comprising a total of 34 participants (Participants'

profiles are presented in table 4). Finally, on the basis of the outcome of the brainstorming session, improvement is suggested to reduce the ambulance response time.

Table 4: Participants Profile for Brainstorming Sessions

Hospital	Category of Participants	No of Participants
Ramkrishna Care Hospital Raipur.	1. Doctors 2. EMT	8
MMI Narayana Hospital Raipur.	3. HoD of Emergency Department 4. Driver 5. Patients and their relatives/caller forambulance	11
Jindal Forties, Hospital Raigarh.	6. Caller, receiver (Manager on Duty)	15
	Total	34

3.2. Formulas for ART CalculationsLog-book format

A time log for a total of 200 calls from 108 services is considered for this study. A typical leaf of the PatientCare Report (PCR)/108 logbook is shown in Figure 2. As illustrated in the figure, an ambulance system consists of six events. These six events follow:

A. Call centre attends the call, takes the details of the Patient, and calls EMT
B. EMT receives the call and travels to the site/ scene
C. EMT & Driver Pickup up the Patients
D. Travel to the hospital with Patient
E. Drops the Patient at the Hospital
F. Goes back to the base station

Figure 2: Patient Care Report (PCR)/108 logbook

Accordingly, for every call attended, a total of six types of times are noted by the ambulance crew. These six times are as follows:

- T1: The time when EMT Receives the Call
- T2: The time when EMT Reaches the Site/Scene
- T3: The time when Depart for the Hospital
- T4: The time when Reaches at the Hospital
- T5: The time when Depart for the Base Station
- T6: The time when Reached the Base station.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 4, February : 2024

Figure 3 Shows the conceptual illustrations of events and time relationship.

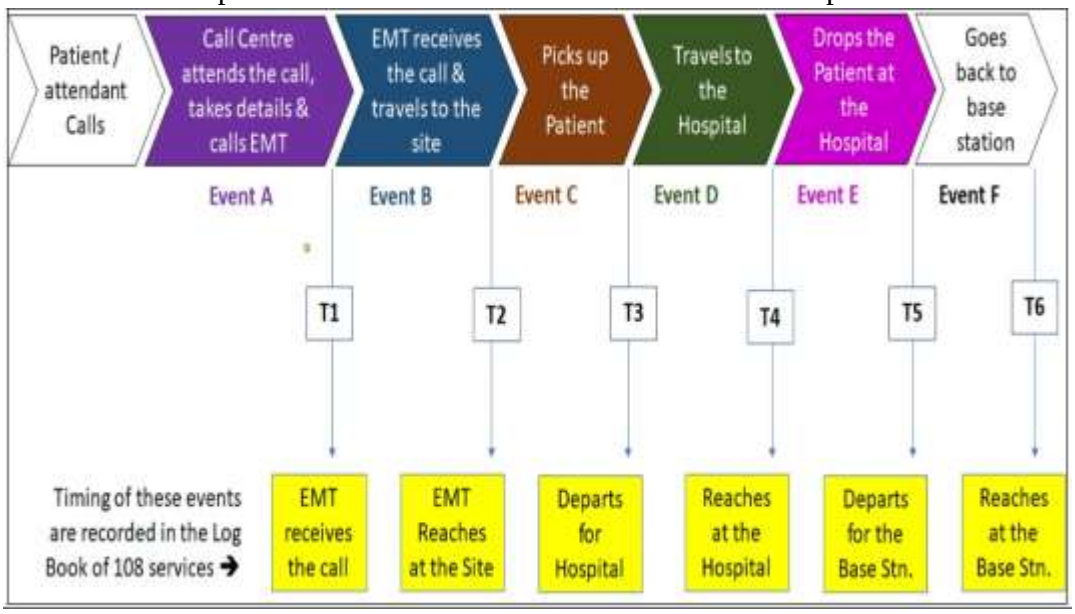

Figure 3: Conceptual Illustration of Events and Time relationship

3.3. Relationship Between the Log Data & Identified Activities of ART

In the context of ART, a total of 28 activities are identified with the help of actual observations by attendingemergency calls with the ambulance crew. It is important to understand the link between these 28 activitiesand the six events discussed above. Therefore, the relationship between these activities and the six events illustrated above is presented in table 5.

Table 5 Relationship Between Key Events and Activities of ART

Event	Activities
A	1. Manager on Duty (MOD) receives incoming calls at the Emergency Response Centre (ERC). 2. MOD inquires the patient details and notes down in the logbook. 3. MOD trace/find the nearest location of an ambulance from the scene.
B	4. MOD informs about the call to EMT (Emergency Medical Technician) or Driver of theambulance. 5. The driver comes towards the ambulance, opens the door and starts the ambulance (Ambulance gets ready with all necessary arrangements, medicines, and equipment). 6. EMT seat in the ambulance with all necessary equipment like a Stethoscope, Pulse Oximeter, BP instrument, Torch, and Medicine like Injection Advenline, Aropine, Dexans, Deriphylline,Sodabitrate, carb, Febrimil, Cylopam, Calgluconate, etc. 7. The driver starts the ambulance and comes outside the hospital and moves to collect thepatient. 8. EMT Contacts with Patient/Patient's relative takes the address and other details about thepatient. 9. Preparation of equipment inside the ambulance by EMT. 10. The driver stops the ambulance.

C	11. The driver and EMT come out from the ambulance and close the front doors 12. The driver and EMT open the back door and take the stretcher. 13. Driver and EMT reach towards the patient. 14. Driver and EMT pick up the patient from the scene or his/her home and placed it in the ambulance. 15. EMT and Patient's relatives (1-2) sit in the ambulance with the patient. 16. The driver closed all the doors of the ambulance.
D	17. The driver comes in, takes the seat, starts the ambulance, and drives the ambulance 18. EMT Carries out first aid treatment. Various activities of EMTs are follows; a) Vaital indications (Pulse, SPO2, Temperature, Blood Pressure, GCS) b) Provides Oxygen mask (if necessary) c) Monitors to the patient d) If the patient is serious, then informs to Head of the Department of Emergency of thehospital and ask which drugs to give to the patient 19. EMT calls Emergency Department (ED) and informs about their arrival 20. Emergency Department (ED) get ready to receive the patient 21. Ambulance enters the hospital and emergency area 22. The driver stops the ambulance, opens the door, comes out, and closes the front door.
E	23. Emergency Department Staff and ward boys' come with a stretcher/wheelchair towards the ambulance. 24. The driver opens the back door, EMT and the patient's relatives come out from the ambulance. 25. Driver, EMT, Emergency Department Staff and ward boys' put the patient on a hospital stretcher and directly go to the Emergency Department of thehospital. 26. Doctors and Paramedical Staff attend to the patient and diagnosis the patient inside theemergency department. 27. After diagnosis, fill out the patient's admission form and other administrative activities are carried out like filling up the forms of the hospital and depositing the payment.
F	28. The driver comes to the base station and parks the ambulance in the parking lot and writes the details about the visit in the logbook and the ambulance with the driver is ready to attend thenext call.

3.4. Distinguishing Standard-Time & Call Dependent Time of the Activities

Standard-Time and Call Dependent Time these two terms are defined as follows;

- **Standard Timing:** Those activities whose execution steps and time required are similar, thus they donot vary significantly on call by call basis. e.g. Preparing the ambulance.
- **Call Dependent Timing:** Those activities whose execution steps and time required vary significantlyon call by call basis. e.g. Travel time depends on the distance.

Executing standard time activity normally requires a similar duration with minimum variations, therefore atime study of sample cases using a stopwatch facilitates a representative figure. Whereas for call-dependentactivity, the time required for execution varies significantly on call to call basis, thus a time-study of the same cases is not deemed as a suitable method. Therefore, in this study, the call-depended activities are studied in terms of Procedure, and SOP.

3.5. Developing Formulas for Calculation of Time

The time note of the Patient Care Report (PCR) starts from, *'the time Emergency Medical Technician (EMT)receives the call'*. Thus, the time when Manager on Duty (MOD) receives the call is not captured in the logbook. The EMT logbook also does not note the time of departure. From the time MOD

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 4, February : 2024

receives the callto the time the ambulance departs from the hospital, there are a total of 6 activities. Since these are standard-time activities (not call-dependent dependent activities), the average time taken for these activities can be estimated with a certain degree of reliability. Accordingly, time estimation for standard time activities in this study is estimated based on the interviews. Wherever feasible, this is further refined by a time study ofsample cases measured during the calls attended by the ambulance crew. As illustrated in figure 4 below, the time gap between MOD receiving the call at the call center of 108 services and EMT receiving the callis termed as Call Time (CT), and the time gap between EMT receiving the call, and ambulance departing for a pick-up is termed as the time taken for Departure or Departure Time (DT). CT and DT for the study are estimated based on interviews followed by a time study of 15 cases/ emergency calls. Subsequently, the following formulas are developed.

Travel Time1 (TT1): The time required to travel from hospital to pick- up location is calculated using the following formula.

$$TT1 = T2- (T1+DT) \quad (1)$$

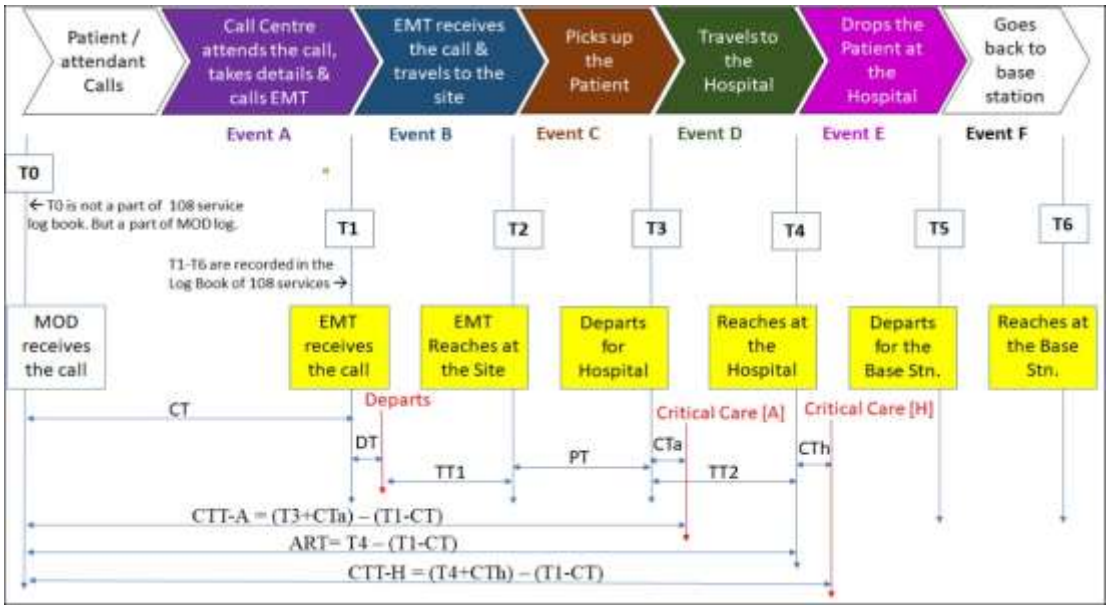

Figure 4: Events of Ambulance Response Time and Time Calculations

Pick-up time (PT): Time gap between the arrival of the ambulance at the site and departure from the site after picking up the patient is called Pick-up Time (PT) and calculated using the followingformula.

$$PT = T3-T2 \quad (2)$$

Travel Time 2 (TT2): The time required to travel from the pick-up location to the hospital iscalculated using the following formula.

$$TT2 = T4- T3 \quad (3)$$

Ambulance Response Time (ART): The Time between receiving the call to dropping the patientto a hospital is calculated using the following formula.

$$ART = T4 – (T1-CT) \quad (4)$$

$$ART = CT+DT+TT1+PT+TT2 \quad (5)$$

Critical-care Treatment Time in Hospital (CTT-H): Time between receiving the call to providing Hospital Critical Treatment to a patient. CTT-H applicable for the case-type is calculated in two steps. First, the time gap between the arrival of ambulances and administration of Critical-Care Treatment in the hospital, applicable for the case type (CTh) is estimated based on interviews. Second, CTT-H is calculated using the following formula.

$$CTT-H = (T4+CTh) – (T1-CT) \quad (6)$$

CTT-H = CT+DT+TT1+PT+TT2+CTh (7)

Critical- Care Treatment Time in Ambulance (CTT- A): Time between receiving the call and providing critical treatment to a patient in an ambulance. CTT-A applicable for the case type (if provided) is calculated in two steps. First, the time gap between the departure of an ambulance from the pick-up location and the administration of Critical-care Treatment, in the ambulance, applicable forthe case type (CTa) is estimated based on an interviews. Second, CTT-A is calculated using the following formula.

CTT-A = (T3+CTa) – (T1-CT) (8)

Similarly it can be calculated using the below formula

CTT-A = CT+DT+TT1 + PT + CTa (9)

In case Critical Treatment in Ambulance is not practiced for the case type then, the notional time of CTT-A is determined using the below formula. The objective of calculating this notional timeis to estimate the time improvement if CTT-A is suggested by the study and adopted for the practice.

CTT-A = CTT-H (10)

Results of implemented of Modified SMED at Selected hospitals.

3.5.1. Call Time (CT) and Departure Time (DT)

The methodology described above, on the basis of 30 interviews CT and DT are respectively estimated tobe about 4-5 minutes and 2-3 minutes. The estimations are further refined by a time study of 15 emergency

Table 7: Ambulance Response Time before Applying Modified SMED

S. No.	Type	No of cases	TT1	PT	TT2	ART	CTT-A	CTT-H
1	Body Pain	10	1141	210	1344	3106	3279	3279
2	Fits	7	554	300	780	2045	2218	2218
3	General Medicine	69	1521	282	1723	3937	4110	4110
4	**Heart**	**29**	**1494**	**490**	**1622**	**4017**	**4190**	**4190**
5	Labour Pain	10	1597	342	1494	3844	4017	4017
6	Not Shift	24	1314	270	1183	3177	3350	3350
7	Poison	9	1278	240	1693	3622	3795	3795
8	Road Traffic Accident	42	1225	424	1306	3366	3539	3539
Weighted Average for 200 cases =			**1370**	**339**	**1491**	**3611**	**3784**	**3784**
*Time in Seconds								

formulas, figure 3, and a tentative proposal for the conversion of internal activities into external activities are prepared. In light of these, brainstorming sessions are organized with each hospital, to identify possibleinternal activities that are converted into external activities. On the basis of the outcome of the brainstormingsession, improvement is suggested to reduce the ambulance response time. The key points recorded in the minutes of the brainstorming activities are given below, and the

improvement suggested on the basis of those points and their impact in terms of expected savings in response time are discussed in the following sections.

- **Key points from brainstorming session**

Conversion of internal activities into external activities suggested in table 8 is possible.

1. Well-trained paramedical staff (EMT) inside the ambulance is expected to facilitate Ambulance Critical Care, which is not provided at present.
2. Complete administrative activities (e.g. filling a patient's admission form, signature on an undertaking by the Patient relatives, etc.) is expected about 2 Minutes.
3. A Software-based ambulance selection is expected to speed up the process and optimize the selection and save a minimum of 120 seconds if not more.
4. Similarly, App-based communication will facilitate speeding up the process e.g. auto recording of information, instant and automatic information transferred to identified ambulances, etc. This will minimize the communication gap and will also eliminate the time required for manual communication. Thus, a saving of a minimum of 60 seconds, if not more.
5. GPS-based navigation including the traffic condition feature is expected to save at least 10% in travel time.
6. Patient handling training and the use of an improved stretcher will improve the safety and convenience of patients and attendants. As well as it will reduce pick-up time at least by 120 seconds.

3.5.2. Improvement in Ambulance Response Time by Applying Modified SMED on Process Common to all Case Types. Based on collected data internal and external activities are distinguished. A tentative proposal for the conversion of internal activities into external activities was prepared. Based on this tentative proposal developed, brainstorming sessions were organized with each hospital, to identify possible internal activities that are converted into external activities. Table 8 shows different activities of the ART process, identifies different activities of ART, separated internal and external activities of ART and the time required for each activity is noted before applying MSMED (H: M: S) as shown in table 8.

Table 8: Identification of internal and external activities of ART and time required for each activity before applying MSMED (H: M: S)

ART Activities	Internal/ External	The time before applying MSMED (H:M:S).
1. Manager on Duty (MOD) receives incoming calls at the Emergency Response Centre (ERC).	Internal	0:00:54
2. MOD inquires the patient details and notes down in the logbook.	Internal	0:02:10
3. MOD trace/find the nearest location of an ambulance from the scene.	Internal	0:02:36
4. MOD informs about the call to EMT (Emergency Medical Technician) or Driver of the ambulance.	Internal	0:01:56
5. The driver comes towards the ambulance, opens the door and starts the ambulance (Ambulance gets ready with all necessary arrangements, medicines, and equipment).	Internal	0:01:50
6. EMT seat in the ambulance with all necessary equipment like a Stethoscope, Pulse Oximeter, BP instrument, Torch, and Medicine like Injection Advenline, Aropine, Dexans, Deriphylline, Sodabitrate, carb, Febrimil, Cylopam, Calgluconate, etc.	Internal	0:01:23

7. The driver starts the ambulance and comes outside the hospital and move to collect the patient.	External	0:00:55
8. EMT Contacts with Patient/Patient's relative takes the address and other details about the patient.	External	0:01:43
9. Preparation of equipment inside the ambulance by EMT.	External	0:01:41
10. The driver stops the ambulance.	Internal	0:00:20
11. The driver and EMT come out from the ambulance and close the front doors.	Internal	0:00:43
12. The driver and EMT open the back door and take the stretcher.	Internal	0:01:53
13. Driver and EMT reach towards the patient.	Internal	0:01:55
14. Driver and EMT pick up the patient from the scene or his/her home and placed it in the ambulance.	Internal	0:02:45
15. EMT and Patient's relatives (1-2) seat in the ambulance with the patient.	Internal	0:01:55
16. The driver closed all the doors of the ambulance.	Internal	0:00:25
17. The driver comes in, takes the seat, starts the ambulance and drives the ambulance.	External	0:00:35
18. EMT Carries out first aid treatment. Various activities of EMT are follows;		
a) Vaital indications (Pulse, SPO2, Temperature, Blood Pressure, GCS)	External	0:03:23
b) Provides Oxygen mask (if necessary)	External	0:04:50
c) Monitors to the patient	External	0:05:02
d) If the patient is serious, then informs to Head of the Department of Emergency of the hospital and ask which drugs to give to the patient	External	0:01:34
19. EMT calls Emergency Department (ED) and informs about their arrival	External	0:00:34
20. Emergency Department (ED) get ready to receive the patient	External	0:00:54
21. Ambulance enters in the hospital and emergency area	External	0:00:52
22. The driver stops the ambulance, opens the door, comes out, and closed the front door.	Internal	0:00:35
23. Emergency Department Staff and ward boys' come with a stretcher/ wheelchair towards the ambulance.	Internal	0:00:52
24. The driver opens the back door, EMT and the patient's relatives come out from the ambulance.	Internal	0:00:37
25. Driver, EMT, Emergency Department Staff and ward boys' put the patient on a hospital stretcher and directly go to the Emergency Department of the hospital.	Internal	0:01:32
26. Doctors and Paramedical Staff attend the patient and diagnosis of the patient inside the emergency department.	Internal	0:05:03
27. After diagnosis, fill out the patient's admission form and other administrative activities are carried out like filling up the forms of the hospital and depositing the payment.	Internal	0:01:23

28. The driver comes to the base station and parks the ambulance in the parking lot and writes the details about the visit in the logbook and the ambulance with the driver is ready to attend the next call.	Internal	0:04:50

After re-examining all internal and external activities of ART, the following internal activities are converted into external activities.

Table 9: Conversion of Internal Activities into External Activities

S. No.	Activities involved in Ambulance Response Time	Internal to external	Time saved due to Internal to External conversion	Remarks
26	Doctors and Paramedical Staff attend the patient and diagnosis of the patient inside the Emergency Department.	External	0:05:03	By providing one Doctor/ well trained paramedical staff (EMT) inside the Ambulance.
27	After diagnosis, fill out the patient's admission form and other administrative activities are carried out like filling up the forms of the hospital and depositing the payment	External	0:01:23	To fill all formats of the hospital related to admission and undertaking must fill inside the ambulance before reached to the hospital.
	Total Time saved due to conversion of internal activities into external activities of ART		**0:06:26**	

3.6. Recommendations for Reduction of ART

1A. Providing one Doctor/well-trained-paramedical-staff (EMT) inside the ambulance facilitates in Ambulance Critical Care, this aspect is discussed in detail in section 3.8. under CTT-A of case type. *Consequently, for Recommendation #1A [EMT], one Doctor/well-trained-paramedical-staff (EMT) inside the Ambulance is expected to improve CTT-A in various quantum depending on applicable cases.* Recommendation #1A [EMT] also makes it possible to provide advance information to hospital which

facilitates advance preparation, thus speeding up in hospital critical care, this aspect is discussed in the section 3.8. under CTT-H of case type.

Consequently, for Recommendation #1A [EMT], one Doctor/well-trained-paramedical-staff (EMT) inside the Ambulance is expected to improve CTT-H in various quantum depending on applicable cases. Expected saving of about 1 Minute (60 sec)

1B. Complete administrative activities (e.g. filling patient's admission form, signature on an undertaking by the Patient relatives, etc.) can be done in an ambulance or after the patient is moved to causality. **Expected saving of about 1 Minute (60 sec)**

Consequently, for Recommendation #1B [AFIA], the completion of Administrative Formalities in Ambulance *is expected to facilitate - A minimum total saving 60 seconds, in context of CTT-H, applicable to all cases.*

Streamlining Operation [SO]

2A. Software-based ambulance selection to identify the nearest available Ambulance. Time-saving in searchplus significant improvement in travel time due to better identification of the nearest available ambulance. Expected improvement CT 4:22 to **2:22 i.e. 142 secs (Saving of 2 Minutes i.e. 120 sec)**

Consequently, for Recommendation #2A [CT], the Software-based ambulance selection is expected to facilitate - A minimum total saving 120 seconds, in context of CTT-A, ART and CTT-H, applicable to all cases.

2B. App-based communication. The call centre receives the call, fills the details on the computer. This infois instantly transferred to identify an ambulance as soon as the ambulance is identified. The lesser time required for discussion plus it minimizes the communication gap.

Expected improvement DT 2:29 to **1:29 i.e. 89 secs (Saving of 1 Minutes, i.e. 60 sec)** *Consequently, for Recommendation #2B [DT], the App-based communication is expected to facilitate - A minimum total saving 60 seconds, in context of CTT-A, ART and CTT-H, applicable to allcases.*

2C. GPS based navigation including traffic condition feature: Its help to minimize travel time. Saving of atleast 10% in travel time. **Hence 10% of average TT1 1370 Sec + TT2 1491 is 286 Sec**

Consequently, for Recommendation #2C [GPS], the GPS based navigation including traffic condition feature is expected to facilitate - A minimum total saving 10%, in travel time in context of CTT-A (TT1) *ART*(TT1+TT2) *and CTT-H* (TT1+TT2), *applicable to all cases.*

2D. Patient handling training to reduce pick up time and use of improved stretcher in addition to improvingthe safety and convenience of patient and attendant. Expected to reduce pick up time, at least by 2 minutes.*Consequently, for Recommendation #2D [IS &PHT] the improved stretcher and patient handling training is expected to facilitate* - **A minimum total saving 120 seconds, in context of CTT-A, ART and CTT-H, applicable to all cases.** These are Common Recommendations [CR] and applicable for all the cases. Table10 presents a summary of improvement.

Table 10: Summary of Improvement

Common Recommendations	ART(Sec)	CTT-A (Sec)	CTT-H (Sec)
1A	0	0	0
1B	0	0	60
2A	120	120	120
2B	60	60	60
2C	10% of TT1	10% of TT1+TT2	10% of TT1+TT2
2D	120	120	120

Actual impact depends on travel time. To exemplify the impact, estimated improvement for each case type,for the data considered in this study, is calculated using the average travel time presented in the Table 11.

Table 11: Illustrates the estimated impact on ART for each case type

Case Type	Before (ART in Sec)	After (ART in Sec)	Saving (Sec)	Improvement
Body Pain	3106	2558	549	17.66%
Fits	2045	1611	433	21.19%
General Medicine	3937	3312	624	15.86%
Heart	**4017**	**3406**	**612**	**15.22%**
Labour Pain	3844	3235	609	15.85%
Not Shift	3177	2627	550	17.30%
Poison	3622	3025	597	16.49%`
Road Traffic Accident	3366	2813	553	16.43%

Recommendation common to case types and their impacts on ART are discussed above.

Recommendationsin context of specific case types their impacts on CCT-A and CCT-H are discussed below.

3.7. Improvement in Ambulance Response Time by Applying Modified SMED on the Case SpecificProcesses

- Proposed Recommendation for *Heart Cases*

CTT-A (Critical Treatment Time in Ambulance): Cardiac cases are known to be life-threatening. "When it's a matter of life and death, every second matter*" The concept of the golden hour is the vital time period of up to one hour by which a patient suffering from traumatic injury or medical emergency should be receiving proper medical assistance to prevent death or irreparable damage to other body parts and organs.*

- **Heart attack:** "A patient suffers a heart attack when the oxygenated blood is unable to reach the heart,which pumps it to the rest of the body". During a heart attack, the heart only partially loses the ability to pump blood. It continues to pump blood but with lower efficiency even when the patient is suffering a heartattack. The prescribed treatment includes helping a person to sit in a comfortable position and giving theman adult aspirin tablet (300mg) and Sorbitrate.
- **Cardiac arrest:** Cardiac arrest can occur suddenly, without any alert or warning. While suffering cardiac arrest, the heart of a patient stops functioning due to problems in an automated external defibrillator (AED) and immediate Cardiopulmonary Resuscitation (CPR) depending on the condition.
- Cardiac-care SOP and training for EMT [H1] in order, to provide medical treatment in the ambulance

1. Provide Oxygen.
2. Does a vital check verify if it's a cardiac problem?
3. Distinguish between Heart Attack and Cardiac Arrest and administer the SOP for the applicable case. The proposed improvement is expected to provide CTT in Ambulance within 5 minutes (CTa= 300 sec) ofdeparture after the pick-up. *Consequently, for Recommendation #H1 [CC-SOP], Cardiac-care SOP and training for EMT in order, to provide in-ambulance treatment is expected to facilitate CTT in Ambulance within (CTa = 300 sec) in the context of CTT-A, applicable to Heart Cases only.*

For impact analysis, expected CTT-A is calculated based on equation 9

- CTT-A = CT+DT+TT1 + PT + CTa

Improved CT = 2:22 as per section 3.6.2A hence 142 Sec.Improved DT = 1:29 as per section 3.6.2B hence 89 Sec.

Improved TT1 = 1494 sec (from Table 7) and 10% improvement as per section 3.6.2C hence 1345 Sec.
Improved PT = 490 sec (from Table 7) and 120 sec improvements as per section 3.6.2D hence 370 Sec.
Hence expected improved CTT-A = 142+89+1345+370+300 = 2246 sec.

Consequently, if both sets of the recommendations namely Common Recommendation *[CR]* as well as Casespecific recommendations *#H1 [CC-SOP]* are implemented together***, CTT-A for Heart Case improves from CTT-H (NV) of 4190 secs (as per the table 7) to 2246 Sec. A saving of 1944 sec (46.39%)***

- CTT-H (Critical Treatment Time in Hospital)

In the prevailing practice, hospital critical care begins after the admission procedure followed by initial assessment, and arrangement of required equipment, tools, devices, and drugs. Treatment to be administeredby paramedical staff is provided. The expert doctor will have called, and treatment to be provided by the Doctor begins upon his arrival. Though all these are implemented quickly, there is a possibility for improvement. Considering that timely critical care makes a difference in life and death, every second counts.In this context, information about initial assessment and treatment provided in the ambulance, if available to the hospital, prior to the arrival of the ambulance, will facilitate the preparation of the material required and allocation of relevant-skill paramedical staff and expert Doctor, prior to the arrival of the ambulance. Thus, it will speed up the process of in-hospital critical

care. This clubbed with Recommendation #1B [AFIA] is expected to facilitate valuable time-saving in CTT-H.

Consequently, Recommendation #1B [AFIA]+ Recommendation #H2 [CC-SOP] i.e. advance preparation of material and allocation of doctor and paramedical staff in the hospital based on the info provided by ambulance EMT, is expected to minimize *CTh under 60 secs, thus a minimum saving of 113 secs, in contextof CTT-H, applicable to Heart Cases.*

For impact analysis, expected CTT-H is calculated based on equation 7.

CTT-H = CT+DT+TT1+PT+TT2+CTh

Improved CT = 2:22 as per section 3.6.2A hence 142 Sec.Improved DT = 1:29 as per section 3.6.2B hence 89 Sec.

Improved TT1 = 1494 sec (From Table 7) and 10% improvement as per section 3.6.2C hence 1345 Sec.Improved PT = 490 sec (From Table 7) and 120 sec improvements as per section 3.6.2D hence 370 Sec.Improved TT2 = 1622 sec (From Table 7) and 10% improvement as per section 3.6.2C hence 1460 Sec.

Hence expected improved CCT-H = 142+89+1345+370+1460+60 = 3466 sec.

Consequently, if both sets of the recommendations namely Common Recommendation [CR] as well asCase specific recommendations #H2 [CC-SOP] are implemented together, ***CTT-H for Heart Case improves from 4190 secs (as per the table 7) to 3466 Sec. A saving of 729 secs (17.29%)***

Table 12: Expected Improvement for Heart Case after the Implementation of Modified SMED

Category of Time	Before (Sec)	After (Sec)	Saving (Sec)	Improvement (%)
CTT-A	4190	2246	1944	46.39%
CTT-H	4190	3466	729	17.29%

Likewise, improvement for all case types were explored as discussed below;

1. In most of the Fits cases O2 has to be provided, and a vital check and Glucose are recommended. Therefore, Recommendation #F1 i.e. by providing effective training to EMTs as well as to the Driver, for vital checks, O2, and Glucose administration, CTT-A could be improved. Consequently, same as the heart case, CTa and CTh are respectively expected to be 300 secs and 60 secs, clubbed with CR, improved CTT-A and CTT-H are respectively expected to be 1209 Sec and 1671 Sec.
2. In Labour pain cases Pre- Hospital care is important; therefore, in Recommendation #L1 one Doctor orMidwife should be inside the ambulance along with EMT to carry out treatment inside the ambulance itselfso that the Patient life will be saved. Consequently, same as the heart case, CTa and CTh are respectively expected to be 300 secs and 60 secs, clubbed with CR, improved CTT-A and CTT-H are respectively expected to be 2190 Sec and 3295 Sec.
3. In Poison Cases Pre- Hospital care is important, therefore Recommendation #P1 one Doctor should beinside the ambulance along with EMT to carry out treatment inside the ambulance itself so that the Patient life will be saved. Consequently, same as the heart case, CTa and CTh are respectively expected to be 300 secs and 60 secs, clubbed with CR, improved CTT-A and CTT-H are respectively expected to be 1801 Secsand 3085 Secs.
4. In the Accidental case street people gathered and disturb the working of the ambulance. Sometimes accident victims fight together because they are not ready to shift to the hospital. Therefore, for such cases,Recommendation #A1 i.e. counseling, as well as Police protection, is helpful for the effective working of the ambulance and the lifesaving of the patient itself. Recommendation #A2 First Aid and other treatmentsin the Ambulance are suggested. Consequently, same as the heart case, CTa and CTh are respectively expected to be 300 secs and 60 secs, clubbed with CR, improved CTT-A and CTT-H are respectively expected to be 1938 Sec and 2873 Sec.
5. For Body Pain, General Medicine, and Not shifted Cases CTh is expected to improve by 60 secs, as perrecommendation 1B. Table 13 presents the expected reduction in time after implementing

the MSMED.

Table 13: Expected reduction in time after implementation of the Modified Single Minute Exchange of Die

Case	Response Time	Before (Sec)	After (Sec)	Improvement (%)	Recommendation
Body Pain(10)	ART	3106	2558	17.66 %	CR (1A-1B & 2A-2D)
	CTT-A	3279	2671	18.56 %	CR
	CTT-H	3279	2671	18.56 %	CR
Fits (7)	ART	2045	1611	21.19 %	CR (1A-1B & 2A-2D)
	CTT-A	2218	1209	45.47 %	CR +#F1
	CTT-H	2218	1671	24.64 %	CR+#F1
General Medicine (69)	ART	3937	3312	15.86 %	CR (1A-1B & 2A-2D)
	CTT-A	4110	3425	16.65%	CR
	CTT-H	4110	3425	16.65%	CR
Heart (29)	ART	4017	3406	15.22 %	CR (1A-1B & 2A-2D)
	CTT-A	4190	2246	46.40 %	CR +#H1
	CTT-H	4190	3466	17.29%	CR+#H2
Labour Pain (10)	ART	3844	3235	15.85%	CR (1A-1B & 2A-2D)
	CTT-A	4017	2190	45.47%	CR +#L1
	CTT-H	4017	3295	17.98%	CR+#L1
Not Shifted(24)	ART	3177	2627	17.30%	CR (1A-1B & 2A-2D)
	CTT-A	3350	2740	18.20%	CR
	CTT-H	3350	2740	18.20%	CR
Poison (09)	ART	3622	3025	16.49%	CR (1A-1B & 2A-2D)
	CTT-A	3795	1801	52.55%	CR +#P1
	CTT-H	3795	3085	18.71%	CR+#P1
Road Traffic Acc. (42)	ART	3366	2813	16.43%	CR (1A-1B & 2A-2D)
	CTT-A	3539	1938	45.24%	CR +#A1+#A2
	CTT-H	3539	2873	18.82%	CR+#A1

- CR: Common Recommendations

4. Validation of the modified SMED methodology

The questionnaire was prepared to carry out desirability and feasibility study, and the proposed revised procedure of ambulance services is an output of the modified SMED methodology. The questionnaire was developed to assess the desirability and feasibility of each of the recommendations on a five-point scale. From the selected hospitals, data were collected from 30 respondents comprising Managers on Duty, Doctors,EMTs, Call Receivers, drivers, Hospital Administrators, and Causality in charge, etc. The list of recommendations was shared with the respondents requesting them to indicate the desirability andfeasibility of each recommendation on a five-point scale ranging from very low to very high. The profile ofthe respondents is shown in Table 14.

Table 14: Respondents' Profile for Desirability and Feasibility Questionnaires

Category	No of Respondents
Doctor	12
Emergency Medical Technician (EMT)	08
Driver	05
Patient/ caller	03
Manager (Call receiver at control room)	02
Total	30

Respondents were asked to indicate the desirability and feasibility of each recommendation on a five-point scale ranging from very low (1) to very high (5). The analysis is done by calculating mean scores. Calculatedscores are shown in table 19 a score of more than three (>3) is considered 'High', between two to three (2-3)is considered 'Medium' and less than two (<2) is considered 'Low'. The desirability of thirteen recommendations is high and two recommendations are medium. The feasibility of ten recommendations is high and five recommendations are medium. High desirability scores indicate that the proposed recommendation is perceived to be beneficial. Whereas the feasibility scores indicate that the proposed recommendations are perceived to be practical. The results show that the recommendations generated by the proposed methodology are mostly beneficial and considerably practical; this validates the methodology. As none of the recommendations scored 'Low' on account of desirability, all recommendations are retained for implementation. Therefore, in phase I, eleven recommendations with 'High' feasibility may be implemented and four recommendations with 'Medium' feasibility may be implemented in phase II. As shown in Table 15.

Table 15: Score of Desirability and Feasibility Study

Proposed Recommendations for Reducing Ambulance Response Time (ART)	Desirability		Feasibility		Implementation Phase
	Mean Value	High/Low	Mean Value	High/Low	
(1a)	3.064	High	2.129	Medium	II
(1b)	3.612	High	3.129	High	I
(1c)	4.000	High	3.741	High	I
(1d)	4.064	High	3.903	High	I
(1e)	3.903	High	3.774	High	I
(1f)	4.096	High	3.967	High	I
(2a)	4.129	High	3.838	High	I
(3a)	4.193	High	3.935	High	I
(4a)	4.000	High	4.225	High	I
(4b)	4.000	High	2.806	Medium	II
(5a)	2.806	Medium	2.129	Medium	II
(5b)	2.290	Medium	2.128	Medium	II
(6a)	3.258	High	2.838	Medium	II
(7a)	3.870	High	3.838	High	I
(7b)	4.064	High	3.9032	High	I

5. Limitations of Study and Scope for Future Work

The limitations and scope of the study provides direction for future studies. For this study data is

collected from select hospitals of Chhattisgarh, India. The modified SMED is applied to three private hospitals in the Chhattisgarh for ART. To develop more confidence on the Modified SMED methodology, it may be appliedin future to many more hospitals including government hospitals of not only Chhattisgarh but also other partsof the country and the World. The Modified SMED methodology was validated by conducting desirability and feasibility study this, is a limited validity exercise. Modified SMED, on similar lines, may be useful forother service industries like case of online food delivery, online parcel delivery, post offices services etc.

6. Conclusions

In this study, a modified SMED is applied for the reduction of ambulance response time at selected hospitalsin Chhattisgarh India. Time reduction ranges from 15.22% to 52.55% indicating that the modified SMED is a suitable methodology for the reduction of ambulance response time.
Validation is done based on mean scores of the 'Desirability-Feasibility Study'. The modified SMED methodology is versatile, unique, and economical, it may be applied at various hospitals and NGOs, and ambulance services in the country.
The modified SMED methodology is unique because most SMED methodology is applied for reducing setup time in the manufacturing industries but it is not applied for reducing response time which is more relevant for the service industries such as ambulance services, firefighting services, food delivery, post office for delivery of articlesor parcel, Online shopping parcel delivery system, etc.

Acknowledgements
The primary author would like to acknowledge the contributions by the secondary authors, who immensely helped the article to reach to its current state by providing their precious time and valuable insights on the subject matter. Authors would like to thanks to the Management of Ramkrishna Care Hospital Raipur, Chhattisgarh, M. M. I. Narayana Hospital Raipur, and Jindal Fortis Hospital Raigarh Chhattisgarh, India. 108 Ambulance Services Raipur, Raigarh, Chhattisgarh India. The primary author would like to thanks to NIT Raipur and OP Jindal University Raigarh, Chhattisgarh India for all-round support and motivations for this research.

Authors' contributions
All authors have contributed to this paper. MSD is the primary author responsible for experimentation, data collection, data analysis and validation, drafting, literature review, and concept development. AMR, MIML and IC are secondary authors for the article responsible for proof reading and peer review of the draft and getting the article submission ready. All authors have read and approved the final manuscript before the submission.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

Availability of data and materials
The datasets used and/or analyzed during the study is confidential in nature and available from the corresponding author on reasonable request.

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

[1] Chin, Su Na., Chen, Sek Yim., Omar, Z, A., Yassin, F, Md., Gabda, Darmesah. 2018. 'Reduction Ambulance Response Time with Ambulance Pre- Deployment Strategy: A Pilot Study'. International Journal of Business and Management Studies. Volume -7 Issue -1, pp.1-8.

[2] Ono,Y., Hayakawa, M., and Iijima, H. 2016. The Response Time Threshold for Predicting Favourable Neurologic Outcomes in Patients with by Stander Witnessed Out-Of-Hospital Cardiac Arrest. International Journal of Resuscitation, 107, pp.65-70. 10.1016/j.resuscitation.2016.08.005.
[3] Lam, Sean Shao Wei., Zhang, Ji., Cheng Zhang, Zhong., and Choon, Hong. 2015a. Dynamic Ambulance Reallocation for the Reduction of Ambulance Response Times Using System Status Management. American Journal of Emergency Medicine, 33, 159–165. https://doi.org/10.1016/j.ajem.2014.10.044.
[4] Lam, Sean Shao Wei., Ngoc, Francis., Nguyen, Hoang Long., and Ng YihYng. 2015b. Factors Affecting the Ambulance Response Times of Trauma Incidents in Singapore. International Journal of Accident Analysis and Prevention, 82, pp.27– 35. 10.1016/j.aap.2015.05.007
[5] Wik, L. 2003. Delaying defibrillation to give basic cardiopulmonary resuscitation to patients with out-of-hospital ventricular fibrillation: a randomized trial. Jama, 289(11);1389-1395. https://doi.org/10.1016/0735-6757(85)90032-4
[6] Dave, Yash., and Sohani, Nagendra. 2012. Single Minute Exchange of Die (SMED) – Review. *International Journal of Lean Thinking*, Volume -3 Issue -2. https://doi.org/10.1007/s00170-019-03484-w
[7] Desai, M. and Rawani, A. M. 2017 Productivity Improvement of Shaping Division of an automobile industry by using single minute exchange of die (SMED) methodology. ARPN J *Journal of* Engineering Applied Science, 12(8);2615-2629 Available: jeas_0417_5949.pdf (arpnjournals.org)
[8] Shingo, S (1985) A Revolution in Manufacturing: the SMED System Productivity Press, 361;1985 https://doi.org/10.4324/9781315136479
[9] Almomani, Mohammed Ali., Aladeemy Mohammed., Abdelhadi Abdelhakim., and Mumani, Ahmad. 2012. 'A Proposed Approach for Setup Time Reduction Through Integrating Conventional SMED Method with Multiple Criteria Decision-Making Techniques'. International Journal of Computers and Industrial Engineering, 66. pp.461–469.https://doi.org/10.1016/j.cie.2013.07.011
[10] Lee, D., Moon, H., and Heo, N. 2019. Association between Ambulance Response Time and Neurologic Outcome in Patients with Cardiac Arrest. American Journal of Emergency Medicine, pp.37-45 https://doi.org/10.1016/j.dss.2012.05.036
[11] Desai, Mukesh Shyamkant., Rawani, A. M., Loya, M. I. M. 2023. Modified Single Minute Exchange of Die for the Reduction of Ambulance Response Time, Industrial Engineering Journal. Volume: 52, Issue 9, No. 2, September: 2023, ISSN: 0970-2555, pp 85-98. 9.2_sep.pdf (journal-iiie-india.com)
[12] Desai, Mukesh Shyamkant., Rawani, A. M., Loya, M. I. M., Meshram, Sachin Akoj., & Desai, Preshit, Mangesh. 2023. The Compatibility Gap Between the Steps of Single Minute Exchange of Die and Activities of Ambulance Response Time. Industrial Engineering Journal. Volume: 52, Issue 8, No. 5, August: 2023, ISSN: 0970-2555, pp 51-67. 8.5_8.pdf (journal-iiie-india.com)
[13] Schmid, Verena. 2011. 'Solving The Dynamic Ambulance Relocation and Dispatching Problem Using Approximate Dynamic Programming'. *European Journal of Operational Research*, 219, pp.611– 621.
[14] Schokry, Abed. 2015. 'Improving the Response Time of Ambulances Using Global Positioning Satellite System (GPS) in Gaza City in the Gaza Strip', Journal of Engineering and Architecture, December Vol. 3, No. 2, pp.63-71.
[15] Subramaniam, Chandrakantan., Ali, Hassan., and Faridahwati, Mohd Shamsudin. 2011. 'Initial emergency response performance of fire fighters in Malaysia', International Journal of Public Sector Management. Vol. 25.No. 1, pp.64-73.
[16] Swalehe, Masoud., Aktas, Semra. Gunay. 2016. 'Dynamic Ambulance Deployment to Reduce AmbulanceResponse Times using Geographic Information Systems: A Case Study of Odunpazari District of Eskisehir Province, Turkey', International Conference on Geographies of Health and Living,Procedia Environmental Sciences, 36, pp.199 – 206.
[17] Ulutas, Berna. 2011. 'An Application of SMED Methodology. *World Academy of Science, Engineering and Technology*'. Turkey 79.
[18] Zarkeshzadeh, Mehdi., Zare, Hadi., Heshmati, Zainabolhoda., and Teimouri, Mehdi. 2015. 'A Novel Hybrid Method for Improving Ambulance Dispatching Response Time Through a Simulation Study'. *International Journal of Simulation Modelling Practice and Theory*. 60, pp.170–184.