Recovering from Distress: The Impact of Critical Incidents on Paramedic Work Performance

by

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B.E. & M.E. Electronics and Communication Engineering
Andhra University, 2015

SUBMITTED TO THE SYSTEM DESIGN AND MANAGEMENT PROGRAM IN PARTIAL FUFILLMENT
OF THE REQURIEMENTS FOR DEGREE IN

MASTERS OF SCIENCE IN ENGINEERING AND MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
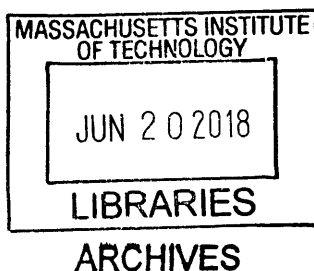
JUNE 2018

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Submitted to the System Design and Management Program on May 05, 2018 in Partial Fulfillment of the Requirements for the Degree of Master of Science in Engineering and Management

ABSTRACT

In many service operations settings, the difficulty of jobs is unpredictable. Examples include police officers or paramedics routinely responding to calls with only limited understanding of the situations awaiting them. In such settings, a worker may occasionally encounter a critical incident (CI), defined as a task or situation which is sufficiently disturbing to challenge or overwhelm the workers' usual coping mechanisms.

We study the impact of complex, stress-inducing tasks on operational task performance of the ambulance crew at the London Ambulance Services (LAS). Our metric for operational performance is cycle times, an important driver of system utilization. Shorter cycle times indicate better performance. From analyzing the LAS data, we found that following a CI, a crew's cycle times increase and the effect gets worse for teams which face more CIs within the same shift. We find that this effect is non-uniform over sub-components of cycle times. In particular, the impact is more significant on operational performance of complex and less standardized tasks. We also did a robustness check for varying definitions of a CI and the results hold and are consistent.

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1. INTRODUCTION

In many service operations settings where people work for public safety and service, the difficulty of jobs is unpredictable. Examples include police officers, doctors, nurses, firemen, psychotherapists. Often, individual tasks are less standardized despite the great organizational systems they may have in place and hence can be very demanding –both physically and mentally. They can induce immediate acute stress leading to symptoms like - a disturbed mind with distressing memories, social detachment, irritability, sleep deprivation. (Brunet et al., 2001). Such distressing incidents are termed as Critical Incidents (CIs) and much research in psychology has been done about the characteristics, causes and impacts of CIs. However, there is absence of an empirical analysis that links the psychology of distressing CIs and operational work performance.

There are many open research questions. First, is there a main effect of this relationship between CIs and operational performance? Since being exposed to CIs is known to negatively affect a person's decision-making abilities (Folkman et al. 1986a), does performance deteriorate immediately following such an incident? Second, how persistent is the negative effect of a CI? Is there a cool off time period after which the impact of a CI disappears? While there is some evidence that CIs can have a long-term impact on emotional wellbeing, does the effect of a single CI to diminish with time? Third question is whether the performance effect of a prior CI is the same for all types of processes. Are effects larger for processes which are more complex or rely to a larger extent on the real-time decision-making capabilities of the workers (Folkman et al. 1986a)? The fourth question concerns possible mitigation strategies. Are there operational measures which can be taken following CIs to mitigate their effects on subsequent performance?

As part of this thesis, we address some of the open research questions. We hypothesize that in a paramedic ambulance setting, CIs have a negative impact on the subsequent operational performance and this effect is worse for more complex tasks. We test our hypotheses using a

dataset from the London Ambulance Service (LAS). The data describes every ambulance activation undertaken by the service during 2011. Our data on 800,000 patient conveying ambulance activations includes time-stamps (e.g., dispatch time, time at scene), crew information, patient characteristics, geographical location of the incident, and the receiving hospital. The setting is ideal for our analysis as the probability of any given paramedic being assigned to a CI is random and exogenous to performance. This allows a clean identification of the effects hypothesized above.

We examine performance in terms of the cycle time of an ambulance activation, and sub-components thereof. The cycle time is defined as the duration from the ambulance dispatch to a particular incident until the ambulance becomes available again. This comprises driving times as well as the time spent at the scene picking up the patient, at the hospital handing a patient over to the ED, and post-handover preparation for the next dispatch. Shortening cycle times is an important objective for LAS. Response times, handover times, and ambulance preparation times are official key performance indicators for paramedics' performance and for most serious health conditions there are significant patient-health benefits of getting to a hospital as quickly as possible (e.g., Sacco et al. 2005).

Since there is no off-the-shelf definition of CIs, for our main analysis, we define CIs to be the ambulance activations involving patients who are so seriously injured that the crew will call ahead to the hospital (known as a "blue call"), alerting the hospital staff of the serious nature of the incoming case; this occurs in about 6% of patient conveying ambulance activations. We use two main independent variables to capture the impact of CIs on subsequent performance. The first, *Post_one_CI* is a binary variable which indicates if the current activation had (only) one CI prior to it during the shift and second, *Post_two_CI* is a binary variable which indicates if the current activation had two CIs prior to it during the shift. The coefficients of these variables capture how the outcome variables (for example, cycle times, response times and handover times) vary post one and two CIs and if the effect gets bigger as number of CIs increase during a shift and if the effect is bigger for some of the more complex tasks. Broadly, our results indicate

that cycle times increase by 1% following a CI and the effect builds up with the crew taking longer post two CIs. Additionally, the relative impact is lesser on simpler, standardized tasks like driving to the scene than when compared to the effect on cycle times, while the relative effect on complex tasks like patient pick up at scene is much worse.

These results have strong academic and managerial implications. Our analysis contributes to the expanding literature describing how psychological factors influence not only workers' wellbeing but also operational performance (Dai et al., 2014). Paramedic crew are used worldwide to deliver care to individuals in emergencies, and as such, they regularly face CIs. Thus, quantifying the detrimental impact of CIs on subsequent performance and investigating operational mitigation strategies is relevant for operations managers responsible for dispatching and scheduling these necessary services.

The following chapters summarize previous literature (chapter 2), study the setting (chapter 3) and data (chapter 5), develop hypothesis (chapter 4), discuss the analysis and results (chapter 6) and finally conclude the research (chapter 7).

2. LITERATURE REVIEW

In Operations Management, much research (both theoretical and empirical) has been done to understand the drivers for operational performance. In behavioral psychology, much theoretical research has been done on CIs and its characteristics, However, there is a gap in understanding how to better link the two streams of literature. The purpose of this research project is to study the impact of CI on the operational performance of ambulance paramedics. In this chapter, we first summarize relevant and significant findings in literature about the drivers of operational performance and what factors play a major role in influencing it. We address both the empirical and theoretical work in the field. Second, we summarize literature on CIs, their causes and their impact.

2.1. DRIVERS OF OPERATIONAL PERFORMANCE

Much empirical research has been done to uncover various factors that affect operational performance, of which organizational processes and management structure is one of the key drivers. Ahmad and Schroeder (2003) provide empirical results for improved performance across countries and industries for when human resource management implements specific useful practices. Samson and Terioviski (1999) conducted an empirical study to determine the relationship between total quality management (TQM) processes and operational performance. Some of the measures and practices of TQM including leadership, people management and a sense of customer focus explain a significant proportion of variance in operational performance. A study by Graff et al. (2002) lists the findings of a committee in emergency medicine about how medical care of emergency medicines can be positively affected by quality improvement measures.

Previous literature also provides both empirical and theoretical evidence for an impact on operational performance by external (environmental) stakeholders in the system like policy makers or the government, other systems/organizations that the organization worked with,

unexpected incidents increasing work load. Kc and Terwiesch (2009) argue that increased workload negatively affects the quality of care delivered by health care delivery services. Even though the staff responds to the increased work load by increasing the throughput, such a performance is not sustainable as the efficacy is affected. Also, major policy changes often affect the operational performance. A qualitative study by interviewing paramedics by Price (2006) discusses that policies identifying appropriate performance metrics and quality indicators play a key role in motivating the crew towards better quality performance. The research argues that a response time target (time taken since the emergency call is received to the time when the crew reaches the scene) of 8 minutes for ambulance services by the UK government is inadequate as a performance indicator. More focus on treating the clock can prove detrimental to the quality of service and hence risk the life of the patients.

Another segment of literature on behavioral drivers for operational performance is individual and team factors, stemming from the employees of the organization. Much research has been done on how productivity is affected by team factors and individual factors. It is reasoned that increased cumulative experience of working together in a team helps share knowledge accumulated by individuals and also understand each other's strengths and weaknesses better and thereby lead to better division of labor and task management. Reagans et al. (2005) argue that procedure completion times shorten with increased team familiarity. It is also discussed that excessive familiarity reduces interactivity of the teams with external environment and stagnates the learning process. An empirical analysis by Aksin et al. (2015) suggests that partner exposure has a positive impact on operational performance in case of less standardized complex tasks. Even on an individual level, several factors can affect productivity. An empirical analysis by Dai et al. (2014) indicates that as work intensity and/or work duration increases, the compliance with rules and standards declines and the compliance improves after the crew got sufficient rest time. Reason (1995) discusses contributions of human errors to the breakdown of complex technologies.

Despite the vast literature on the various drivers affecting operational performance, there is notable absence of empirical evidence indicating a negative impact on operational performance

following a stressful CI on a team/individual. This leads us to further study the next stream of literature which is based on CIs.

2.2. PSYCHOLOGY OF CIs

In public service operations settings, the service personnel often encounter CIs as part of their job. Halpern et al. (2012) define a CI as a stressful incident at workplace that induces acute distress and may negatively affect short term or long-term operations. Miller (2006) indicates how certain personnel in public safety jobs like police officers, nurses, psychotherapists undergo traumatizing incident stress. A qualitative study by Halpern et al. (2012) presents various characteristics of CIs in the work setting of ambulance paramedics for example, an incident where the crew felt helpless, a destructive-near-death situation, an experience where the crew member had to risk their own life while attending a patient, an experience of treating a friend, family or someone they were close to, a situation with massive human life damage and situations depicting cruelty, can all be very traumatic and are termed as CIs. From Brunet et al. (2001), we can classify post CI stress into two types. First, Peritraumatic stress, which is immediate distress around the trauma, can lead to acute stress reaction which commonly includes distressed mind, often leading to sleep deprivation, social detachment, disturbing memories and affecting the physical well-being, and lasts from a few hours to a few days. Second, Post-traumatic stress disorder (PTSD). Continued exposure to such acute stress and unrest often leads to its long-term outcomes of depression, PTSD and burnout symptoms. Stewart and Swartz (2014) provide some of the most common PTSD with symptoms such as feeling irritable or having outbursts of anger, unable to feel emotions, feeling jumpy or startled, feeling as if there is no future and losing interest in daily activities. Although peritraumatic distress is usually a response to a particular event's anguish, it can be a presage to the bigger tribulations later.

In summary of the above literature, work performance is majorly a coalescence of one's well-being (physical and mental), knowledge and relevant skills, motivation, resources, organizational systems at work. Wyk's (2011) qualitative analysis indicates that a CI has a major impact on the employee's subsequent work performance. A disturbed psychological state

affects an employee's motivation, ability to put his/her skills to use, ability to make use of the resources appropriately and following the systems in place. CIs have a negative effect on the employee's psychological functioning and hence performance deteriorates Wyk (2011). Folkman et al. (1986a) argue that distressing CIs can affect one's coping mechanisms by evoking cognitive appraisal and thereby lead to judgement errors and hence translate into bad encounter outcomes. As the crew continues to work in its distressed state, it can translate into bad outcomes, thereby impacting the lives of the people they serve. This is where the problem becomes even more serious. LeBlanc et al. (2005) conduct a study by inducing task contingent stress on health care personnel and provide evidence that performance regarding the calculation of drug doses is negatively impacted in cases of stress and that even in case of highly experienced individuals, stressors experienced in medical circumstances can make room for clinical inaccuracies.

While previous literature related to CIs' impact on work performance is very useful theoretically and gives insights into the reasons, scenarios and effects of CIs on work performance, it has its limitations in terms of the quality of the data used for analysis. It has low response rate with the uncertainty as to whether the study population is representative of all paramedics (Halpern et al. 2012). The results are not inclusive of the entire population because of the methodology used (since most are self-reported with the lack of objective performance outcomes). If the research is a retrospection, it creates room for bias and misjudgment because of self-selection of responses. Some research is based on task contingent stress by observing operational performance of a small group of people. However, peripheral stress is different from task-contingent stress and the results hence might not be very robust (LeBlanc et al., 2005).

Despite the theoretical literature about traumatic impacts of CIs, little is known about how and if it affects operational performance. In this paper, we bridge the gap between drivers of operational performance and psychology of CIs and how they may impact productivity. We conduct an empirical analysis using a unique inclusive of varied population and live operational work performance by controlling for big data and variables.

In summary, our contributions are three-fold. First, using LAS's operational performance data, we show that post CIs, on account of acute stress, work performance deteriorates. Second, this effect is relatively more significant in tasks which are less standardized and depend more on the crew's presence of mind. Third, irrespective of the cause and kind of trauma, this effect is always observed. Hence our results show that CIs have a negative impact on paramedic work performance. To our knowledge, this is the first research project to conduct an empirical analysis to understand the impact of CIs on operational performance.

3. SETTING

We test our hypothesis using data from LAS. In this chapter, we first provide a brief introduction to LAS as an organization and then understand operational practices and systems at LAS.

3.1. THE ORGANISATION – LAS

LAS, which a part of NHS, is the busiest ambulance service in UK and provides health care service within London. LAS has about 5000 staff members who work for public safety in 70 service stations spread across the city. Providing emergency medical care being its main role, LAS responds to 999 emergency calls, 24 hours a day, 365 days a year. At its headquarters, a control center, receives, classifies and transfers all emergency calls to one of the three dispatch desks (West, East and South), depending on the geographical distance from the emergency scene. Each dispatch desk encompasses six dispatch sectors, each of which has a designated dispatcher, who dispenses ambulances to emergency calls as required.

3.2. THE OPERATIONS – AMBULANCE SYSTEMS AND PROCESSES

Majority of the patient conveying activations involve an ambulance and the there are two people per ambulance (true in 94.5% of the cases). Hence, we focus our study on two crew member ambulance activations. The transport processes the crew follows are as follows:

3.2.1. Dispatch to the scene – Drive to the scene time: The control center receives emergency 999 calls and collects information about the patient – the incident's location, contact phone number, description of the incident, patient age, gender, medical history, current state of the patient – conscious, breathing, bleeding, chest pain and other details of the injury. With all the information noted, the emergency call is triaged to a dispatcher who sees the emergency call's location and severity on his/her computer terminal. The dispatcher makes a dispatch decision based on the location and status of emergency vehicles (car, ambulance, motorcycle or bicycle) available nearest to the location of the call. Once they receive a call from

the dispatcher informing about the next activation, the crew tries to drive to the scene as soon as possible.

3.2.2. Patient pick up – Scene Time: As the crew arrives at the scene, they need to examine the patient's condition, stabilize the patient, alleviate their pain and take first aid action if required, and bring the patient into the ambulance for transport to an Accident and Emergency Department (A&E). This part of the crew's job is complex, unpredictable and less standardized. The time spent at the scene is variable depending on clinical and non-clinical dimensions at the scene.

Clinical challenges include understanding the patient's condition and making decisions about how much to treat versus how fast to get them to the hospital, what drugs to administer, and how to maintain or improve patient's status. The non-clinical and logistical tasks that the crew sometimes encounters, makes the situation even more demanding – for example, dealing with non-patients, policies and other formalities, chaos at the scene, bringing the patient to the vehicle. (Aksin et al. 2015). Hence, many factors like crew's physiological and psychological well-being, crew's age, experience and knowledge, team relationship and fatigue play a key role in the patient pick up performance.

3.2.3. Driving the patient – Drive to the hospital time: Once the patient is brought to the ambulance, one of the crew members monitors the patient's condition and attends to him/her, while the other member locates the nearest A&E and drives the ambulance via the shortest and fastest route possible.

3.2.4. Patient Handover –Hospital Time: In the UK, except some serious emergency cases, the patients arriving at the hospital via an ambulance enter through a special entrance but are not prioritized over the regular patients already waiting at the hospital, in order to avoid over utilization of the ambulance when not obligatory. The patient is handed over to the A&E in two steps. First, the crew communicates the clinical information to the available triage nurse. The triage nurse follows the customary checklist, the patient's condition, results of diagnostic tests (if any) and allocates the patient to one of three A&E units namely – minor incidents, major incidents, or resuscitation. Second, once the patient is allocated a bed, the crew moves the patient to the respective unit as directed by the triage nurse, carefully places

the patient on the bed as suggested by the head nurse of that unit, and receives a signed letter from the head nurse of that unit, confirming a safe handover of the patient.

3.2.5.   Preparing the Ambulance – Preparation Time: After a safe handover of the patient at the A&E, the crew takes some time before it indicates itself available for the next activation. The crew utilizes this time for cleaning the ambulance, changing or discarding sheets/covers, replenishing the ambulance with medical supplies, making sure they have everything they need for the next call or just taking a break from a long and strenuous activation. Once they mark themselves green (ready for next activation), they are soon assigned to another call. The time at which they go green is called the green time.

3.2.6. Cycle time - Time per Operation: Cycle time is the total time the crew takes from when the ambulance dispatches to when the ambulance indicates itself ready for the next activation. It is the total duration the ambulance is busy with the activation.
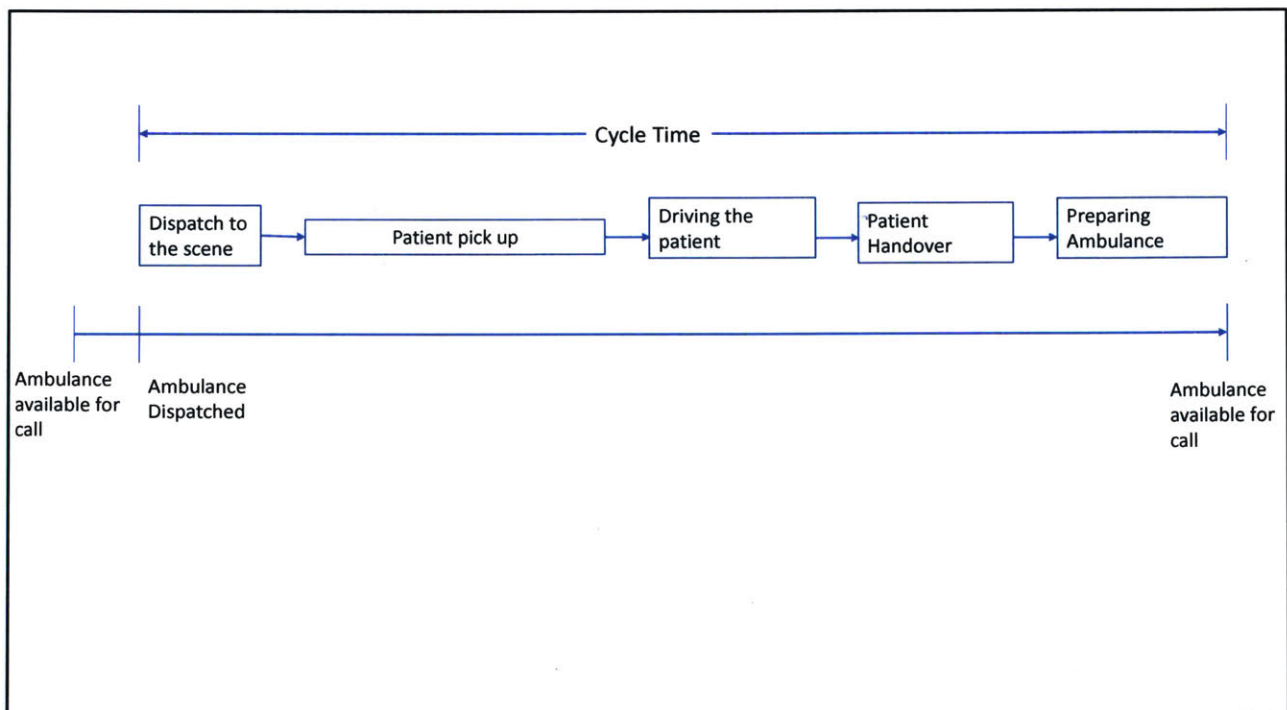

Figure 3.1. Transport processes at LAS

4. HYPOTHESIS DEVELOPMENT

Ambulance paramedics work 8-12 hours a shift. They very often encounter stressful incidents (we have data indicators for some of these) like severe incidents involving an assault, a child, alcohol, violent crime, treating someone related. (Halpern et al. 2012). These tasks are very demanding and cause immediate distress which can be termed as CIs (Brunet et al. 2001). In addition, the ambulance crew does not have much resting time between activations (less than 18 minutes for 50% of the activations). Since the crew does not have control over the activations they are assigned, the stress effect often builds up as they sometimes encounter more than one CI during the same shift. These distressing CIs affect the coping mechanisms and decision-making capabilities of the crew leading to judgement errors and translate into bad encounter outcomes (Folkman et al. (1986a).

As discussed in section 3.2., the ambulance crew goes through various tasks during an activation. The tasks involved are not completely standardized and the operational performance depends much on the expertise and quick decisions of the crew. The crew faces clinical challenges during an activation like - stabilizing the patient by administering required care by concisely examining the patient, connecting and informing to the nearest A&E to prepare for the arrival in case of serious calls. Some of the non-clinical challenges include - attending and communicating to the related people, bringing patient to the vehicle in case accidents or assaults.

If the crew has experienced a distressing CI earlier in the shift, it is likely that they are not in the best psychological state because of the resulting peritraumatic stress (Stewart and Swartz, 2014). Given the distressing emotions, irritability, physical arousal, and social withdrawal, the crew is likely to make wrong judgements, be absent minded, be slow, take longer to make decisions and make errors, overall leading to longer cycle times (Halpern et al. 2012). Hence, it is very likely that CIs negatively affect operational work performance.

This theory leads us to the first hypothesis.

H1: During a shift, Time per Operation is longer for the activations following a CI

An activation has various transport processes as discussed in section 3.2. Some of the tasks are more complex and require better cognitive abilities and decision-making skills. In such a case, a complex task after a CI is likely to have more impact than on that of the total cycle time after a CI.

Drive to scene time: This is a simple and fairly standardized task. While one crew member takes the shortest route possible to reach the scene, the other crew member is idle. This task does not challenge the cognitive abilities and does not test the crew's judgement. Hence, it is likely that driving to the scene after a CI is likely to have lesser impact than on that of the total cycle time after a CI.

H2A: The relative impact of CIs on subsequent performance on drive to scene time is lower than that on cycle time.

Scene Time: This is the most complex task of the entire job. As discussed in section 3.2.2, this requires complex and critical thinking abilities. The performance depends on the crew's judgement and expertise since it is an unpredictable and less standardized job. If the crew is already distressed from a previous CI during the same shift, the patient pick up situation can add to the total stress and make it harder for them to cope (Folkman et al. (1986a). Hence, it is likely that patient pick up after a CI is likely to have more impact than on that of the total cycle time after a CI.

H2B: The relative impact of CIs on subsequent performance on scene time is more than that on cycle time.

Drive to hospital time: This is also a fairly standardized task. While one crew member takes the shortest route possible to reach the hospital, the other crew member is monitoring the patient. This task does not challenge the cognitive abilities and does not test the crew's judgement. This

task does even require much expertise of the crew. Hence, it is likely that driving to the hospital after a CI is likely to have lesser impact than on that of the total cycle time after a CI.

H2C: The relative impact of CIs on subsequent performance on drive to hospital time is lower than that on cycle time.

Hospital time: While this is not as simple a task as driving, this is a fairly standardized job. As discussed in section 3.2.4, the crew hands over the patient to the hospital staff and completes some formalities before leaving. Since the operational performance is not solely dependent on the crew but also the hospital staff and driven by the protocol there, the joint operation reduces any deviation from job and any variance in operational performance on account of any previous stressors the crew might have faced. Hence, it is likely that hospital time after a CI is likely to have lesser impact than on that of the total cycle time after a CI.

H2D: The relative impact of CIs on subsequent performance on hospital time is lower than that on cycle time.

Preparation time: This is the time the crew takes to prepare the ambulance for the next activation. This task is simple – for example, changing sheets, replacing and restocking medical supplies. Since the task is not standardized and the crew is not chasing any clock, it is likely that preparation time after a CI is likely to have lesser impact than on that of the total cycle time after a CI. However, if the crew is very distressed, they might choose to take longer before they are ready for the next activation.

H2E: *The relative impact of CIs on subsequent performance on preparation time is lower than that on cycle time.*

5. DATA

We use LAS's one year (2011) data of all the activations of over 4000 crew members for the 807,208 patient conveying activations. Since the non-patient conveying activations are rather short and the affect rather insignificant, we decided to work only with the patient conveying activations for this project. The data could be categorized as below:

1. Patient related clinical information: Patient's age, gender, urgency categories such as – Advanced Medical Priority Dispatch System (AMPDS), Department of Health (DOH), LAS, illness codes, indicators for blue call, if the incident is alcohol related and if the incident is an assault.

2. Scene related logistical information: Easting and northing of vehicle at the time of activation and area code of the incident.

3. Timestamps: Call started, call ended, dispatched, arrived at scene, left scene, arrived at hospital, patient handover, green time.

4. Operational activation information: Activation ID, ambulance vehicle number, hospital code.

5. Crew Information: ID, year joined, year born and grade name.

5.1. METRICS FOR PARAMEDIC PERFORMANCE

In LAS, the level of service is determined by patient outcomes. The more people the organization is able to help and serve, the more it is being used and an indication of a better operational performance. Hence, cycle time is a critical performance metric in this case.

As mentioned in section 3.2, the crew follows various steps during patient transport process - respond to the call, reach the scene, stabilize the patient at the scene and bring the patient to the ambulance, drive to the hospital, handover the patient at the hospital and prepare for the next activation. While the drive to the hospital and patient handover do not require much coping skills and are rather standardized, handling the patient given the clinical and non-clinical

challenges at the scene, requires sound psychological well-being. CIs affect psychological well-being of the crew and hence their decision-making capabilities. Although the crew is expected to follow standardized processes, a great deal of work performance still depends on the quick decision making and on-the-go-judgement calls of the paramedics. The following section will build on this thought and define the variables which we use as the outcome variables in the analysis.

5.2.   CI AT LAS

A CI in the LAS setting is any activation which is a traumatizing incident and that can leave an impact on the paramedics. There is no off-the-shelf definition for CIs. Hence, as part of this analysis, we have decided to define CIs as serious incidents. Some of the CIs definitions that will be used are discussed below:

Blue call: A blue call is an extremely serious incident. The ambulance crew skips the regular procedure and directly alerts the A&E to prepare for their arrival and take the patient in. These activations are very stressful for the crew and hence we decided to go with this definition for CI. There are 44,578 blue call activations in the data. A blue call, with an average cycle time of 89 minutes, is typically 8 minutes longer than a regular activation which has an average cycle time of 81 minutes, despite the fact that they take special care to reduce to the overall time spent waiting at the hospital and doing special procedures before handover. The graph below shows how a CI compares to a regular activation:
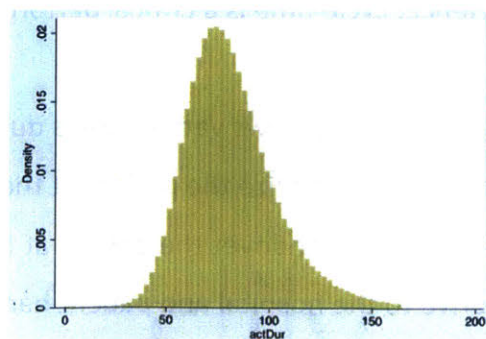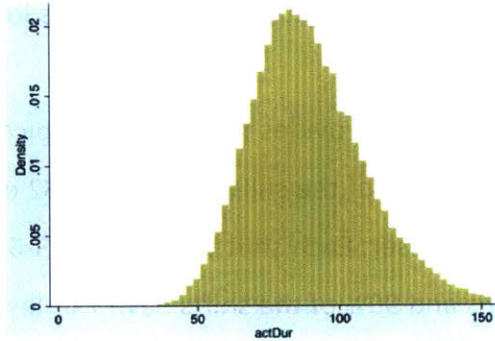

Fig 5.1. Regular activation

Fig 5.2. CIs

The following are some of the other definitions of CIs we experimented with:

i.   Blue call with a child (Patient age less than 12 years)

ii.   Alcohol related Blue call

iii.   Blue call which was an assault

iv.   AMPDS category D or E (near death experiences)

v.   Child with AMPDS category D or E (near death experiences)

Blue calls are very serious medical calls. When these calls are associated with alcohol, crimes like assault, or involve a child, they can be even more traumatizing. LAS prioritizes calls using the AMPDS categories and category D or E are serious medical conditions. Hence, we define CIs using these different variables.

5.3.   DEFINING SHIFTS

LAS' crew does not follow have specific shift times. In the data, there was no indication as to when the teams began and ended their shifts. Hence, we defined shifts based on the delay between activations, which is the time between greentime after previous activation to the dispatch time of the current activation. This delay between activations varies with activations but for 50% of the activations, it is 18 minutes or lesser, indicating that the teams are usually quite busy. The LAS data providers also mentioned that a typical shift was about 8-12 hours

long. Hence, by plotting a histogram of delay between activations, we realized it is fairly reasonable to call it a shift if the delay between dispatches is longer than 320 minutes.

The shift structure hence obtained provides that a shift is typically 600-700 minutes long, which is between 10-12 hours. The mean of the shift duration is 582 minutes, and 90% of the shifts are as long as 700 minutes or lesser. Each shift typically has 3-6 patient conveying activations. The mean is 4.37 activations and 90% of the shifts have 7 or lesser patient conveying activations.
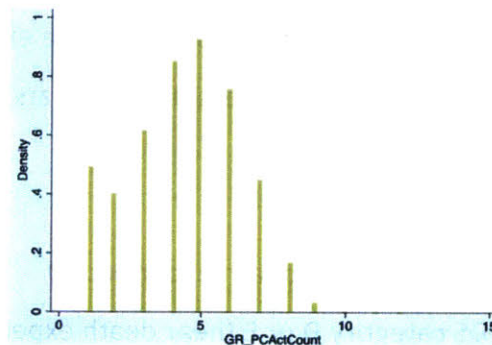
Fig 5.3. Patient conveying activations during a shift

5.4. IMPORTANT VARIABLES USED IN THE ANALYSIS

This section gives an overview of the most significant variables used in the analysis. The variables are broadly classified into the following categories:

5.4.1. Outcome variables: As discussed in section 5.1, the paramedic performance at LAS is determined by the speed of operation. The faster they operate, the better the performance. Hence, outcome variables are defined as follows to quantitatively measure performance. The following variables, as listed in table 5.2 shall be the outcome variables in the analysis to follow, measuring performance of the system.

Table 5.1 Outcome Variables

Performance Metric Delay Variable	Description
Drive_to_scene time	Time* since the call was received to arrive at the scene.
Scene_time	Time since arrived at the scene to leave the scene with the patient.
Drive_to_hospital time	Time since left the scene to arrive the hospital
Hospital_time	Time since arrived at the hospital to patient handover (Turnaround time)
Preparation_time	Time since patient handover to going green
Time_per_operation	Time since call was received to going green (Total time per activation)

* time is measured in minutes.

5.4.2. Independent variables: The following are the key independent variables used as part of the analysis.

Post_one_CI: A binary variable which is 1 for activations within a shift after one CI. Although CIs happen without any variability in the data, a positive correlation between the Post CI variable and the Delay in the Time per Operation would strongly support our hypothesis.

Post_two_CI: A binary variable which is 1 for activations within a shift after two CIs.

Critical_Incident: This is a binary variable which is 1 if the activation is a CI. It was already discussed that CIs have longer cycle times, however, we are more interested to see the cycle times following CIs.

Shift_Utilization: This is the ratio of the time the team was busy in any activation versus the total time during the shift. This would be 1 if there were no breaks between dispatches during the entire shift. If the shift has more utilization, the team is likely to be tired and have symptoms of fatigue. Also, the more the utilization, more the compromise on patient safety and performance (Kc and Terwiesch, 2009)

Time_Since_Start: This is the time since the first dispatch of the shift to the dispatch time of the current activation. The longer the crew has been working in the shift, greater is the fatigue effect, which is associated with compromised rule compliance and reduced performance (Dai et al., 2014)

5.4.3. Control variables: The following are the variables we control for, as part of the analysis:

Activation_Number: The activation number of the current activation during the shift.

PC_Activation_Number: The patient activation number of the current activation during the shift. (ignoring the non-patient conveying activations in the shift).

The effect of fatigue increases as activation number increases (Kc and Terwiesch, 2009 and Dai et al., 2014), thereby affecting work performance.

5.4.4. Fixed effects: We incorporate few indicator variables to account for unobserved heterogeneity.

Group_ID: This variable is a unique identification number per team combination. Each team has crew members with varied experience, age and grade/position. While all this can determine a team's performance to a great deal, even the team familiarity and chemistry plays a critical role in the performance (Aksin et al., 2015). Hence it is critical to absorb for this effect to measure the performance irrespective of team factors.

Hospital_Code: Each hospital has an identification code. Controlling for the hospital code takes into the account the variabilities that may be exist due to the location, the procedures, patient traffic and hence the wait times.

Hour_of_day, Day_of_week, Month_of_ year: Controlling for these variables is important to avoid any bias that may be creep in because of certain seasonality factors. For example, road and hospital traffic during busy hours versus late night times, Incidents during certain days of the year which might increase the traffic at hospitals and reduced road traffic during weekends.

AMPDS_Code: This variable may also contain some biases in the outcome variables given the category. While some serious cases might involve immediate patient pickup and fast transfer, some others might also require stabilizing the patient and proving some urgent care at the scene. This greatly determines the outcomes.

LAS_Category: While LAS follows the AMPDS code system to categorize an incident, it also has its own codes to categorize incidents as 1) Life threatening 2) Emergency 2) Urgent 3) Less urgent.

6. ANALYSIS AND RESULTS

In this chapter, we present the regression specifications and analysis using the data from chapter 3 and the results hence derived. We also interpret the results and discuss how the results presented, support the hypothesis. We chose to do a regression analysis to see how the dependent variables listed in 5.4.1 get impacted with the variability in the independent variables discussed in 5.4.2, how these variables interact, which of the outcome variables are the most impacted and which of the independent variables cause the most impact. Doing a regression analysis adds more robustness to this project of data analysis and gives the opportunity to include fixed effects and avoid any bias that may creep in.

As part of this process, we decided to focus our analysis on a subset of data - shifts with one or two CIs only. We did some analysis to see how the CIs are distributed across a shift and the results imply that there is no trend there. Hence, we know that there is no bias and the coefficient for fatigue and coefficient for CI effect can both be determined.

6.1. IMPACT OF CIs ON WORK PERFORMANCE

$$
\begin{aligned}
\text{Time\_per\_operation} = {} & \alpha_1 + \alpha_2 \text{ Post\_one\_CI} + \alpha_3 \text{ Post\_two\_CI} + \alpha_4 \text{ Critical\_Incident} + \\
& \alpha_5 \text{ Shift\_Utilization} + \alpha_6 \text{ Time\_Since\_Start} + \alpha_7 \text{ Activation\_Number} + \\
& \alpha_8 \text{ PC\_Activation\_Number} + \alpha_9 \text{ Group\_ID\_FEs} + \alpha_{10} \text{ Hour\_of\_day\_FEs} + \\
& \alpha_{11} \text{ Day\_of\_week\_FEs} + \alpha_{12} \text{ Month\_of\_year\_FEs} + \alpha_{13} \text{ AMPDS\_code\_FEs} \\
& + \alpha_{14} \text{ LAS\_Category\_FEs} + \alpha_{15} \text{ Hospital Code\_FEs} + \epsilon
\end{aligned}
$$

As discussed in the previous chapters, the main topic of interest is the time per operation, the indicator of work performance in case of Paramedics. The regression equation above includes number of variables but $\alpha 2$ and $\alpha 3$, the coefficient of Post CI, if positive, would imply an increase in time per operation, which denotes a negative impact on paramedic work performance. In this section, a CI is a blue call. The other independent variables as discussed in 5.4.2 are also included in the above equation, along with the control variables and the fixed

effects from 5.4.3 and 5.4.4 respectively. To account for autocorrelation in the unobservable factors, we determine clustered standard errors – an error term ϵ.

The results from the regression are shown in table 6.1. The first column in the table reports the results for time per operation as an outcome variable from 185,713 observations. Analyzing the results, we notice that the results are highly significant. Positive coefficient of *Post_one_CI* denotes that following a CI, time per operation increases. It takes 0.7 minutes longer and the coefficient of *Post_two_CI* which is bigger suggests that the negative impact of CIs build up and it takes even longer for the crew post two CIs by 1.1 minutes. Since the average number of patient conveying activations in a shift are 5 (from figure 5.3), this means a total delay of 5.5 minutes per shift. The average time per operation for a regular patient conveying activation is 78 minutes and from the results we understand that the paramedics cycle times increase by 1%. In an ambulance setting, this is quite a significant number. This supports the hypothesis H1 that CIs negatively affect work performance

CIs have a positive coefficient which denotes that CIs take longer cycle times. The time per operation is 8.2 minutes more than a regular activation. These results also indicate the effect of fatigue. Positive coefficient of *Shift_Utilization* indicates that the crew takes longer cycle times if they have been busier during the shift. Also, a negative coefficient of *Time_Since_Start* indicates that the crew takes shorter cycle times as they approach the end of shift.

Table 6.1 OLS coefficient estimates for regressions with blue calls as CIs

	Timeperop	To Scene	At Scene	To hospital	At hospital	To prep
Post_one_CI	0.801***	0.062*	0.481***	0.108*	0.032	0.05
	(0.13)	(0.03)	(0.08)	(0.04)	(0.06)	(0.06)
Post_two_CI	1.194***	0.078	0.524**	0.112	0.014	0.320**
	(0.25)	(0.06)	(0.16)	(0.09)	(0.11)	(0.12)
Critical_Incident	8.720***	-0.105***	4.217***	-3.348***	-3.991***	11.182***
	(0.12)	(0.03)	(0.08)	(0.04)	(0.05)	(0.06)
Shift_Utilization	1.417*	0.519***	-1.615***	0.543**	1.837***	0.443
	(0.58)	(0.14)	(0.38)	(0.2)	(0.26)	(0.28)
Time_Since_Start	-0.031***	-0.001**	-0.010***	-0.002***	-0.006***	-0.011***
	0	0	0	0	0	0
R-sqr	0.311	0.219	0.295	0.261	0.313	0.449
N	185811	185724	181114	180684	166063	167416

* p<0.05, ** p<0.01, *** p<0.001

6.2. AFFECT OF CIs ON VARIOUS TASKS

Since we understand that CIs affect cycle times, we want to study if this effect is more prevalent and stronger in more complex tasks. Hence, in this section, we break down the cycle times into various tasks and repeat the same regression study. The results for this section are presented in table 6.1.

6.2.1. CIs and work performance during the drive to scene:

$$Drive\_to\_scene\_time = \alpha_1 + \alpha_2 \, Post\_one\_CI + \alpha_3 \, Post\_two\_CI + \alpha_4 \, Critical\_Incident +$$
$$\alpha_5 \, Shift\_Utilization + \alpha_6 \, Time\_Since\_Start + \alpha_7 \, Activation\_Number +$$
$$\alpha_8 \, PC\_Activation\_Number + \alpha_9 \, Group\_ID\_FEs + \alpha_{10} \, Hour\_of\_day\_FEs$$
$$+ \alpha_{11} \, Day\_of\_week\_FEs + \alpha_{12} \, Month\_of\_year\_FEs + \alpha_{13}$$
$$AMPDS\_code\_FEs + \alpha_{14} \, LAS\_Category\_FEs + \epsilon$$

Driving to the scene is a fairly simple and standardized job. One of the crew members takes the shortest distance and drives to the scene while the other crew member is idle. In section 6.2.1, our focus is on the drive to scene time as an outcome variable (see column 2 in table 6.1). From the results, with a positive coefficient of *Post_one_CI*, it is evident that the crew takes 0.06 minutes longer to drive. And *Post_two_CI,* the crew takes 0.08 minutes longer to drive. The average time to drive to a scene for regular activations is 8.2 minutes. Hence, following a CI, the crew takes 0.75% more time to drive to the scene. When compared to the cycle time, this effect is smaller. This supports the hypothesis H2A.

6.2.2. CIs and work performance at the scene:

$$Scene\_time = \alpha_1 + \alpha_2 \ Post\_one\_CI + \alpha_3 \ Post\_two\_CI + \alpha_4 \ Critical\_Incident + \alpha_5 \ Shift\_Utilization + \alpha_6 \ Time\_Since\_Start + \alpha_7 \ Activation\_Number + \alpha_8 \ PC\_Activation\_Number + \alpha_9 \ Group\_ID\_FEs + \alpha_{10} \ Hour\_of\_day\_FEs + \alpha_{11} \ Day\_of\_week\_FEs + \alpha_{12} \ Month\_of\_year\_FEs + \alpha_{13} \ AMPDS\_code\_FEs + \alpha_{14} \ LAS\_Category\_FEs + \alpha_{15} \ Hospital \ Code\_FEs + \epsilon$$

Patient pick up is a complex task as discussed in 3.2.2. The tasks at the scene are unpredictable and unstandardized and crew has to make multiple decisions about how to deal with the situation given the clinical and non-clinical challenges. In section 6.2.2, our focus is on the *Scene_time* as an outcome variable (see column 3 in table 6.1). From the results, with a positive coefficient of *Post_one_CI*, it is evident that the crew takes 0.48 minutes longer at the scene. And *Post_two_CI*, the crew takes 0.52 minutes longer at the scene. The average time at scene for regular activations is 27.2 minutes. Hence, following a CI, the crew takes 2% more time at the scene. This effect is double the effect on the total cycle time since it is a complex task. This supports the hypothesis H2B.

6.2.3. CIs and work performance during the drive to hospital:

$$\text{Drive\_to\_hospital\_time} = \alpha_1 + \alpha_2 \text{ Post\_one\_CI} + \alpha_3 \text{ Post\_two\_CI} + \alpha_4 \text{ Critical\_Incident} + \alpha_5 \text{ Shift\_Utilization} + \alpha_6 \text{ Time\_Since\_Start} + \alpha_7 \text{ Activation\_Number} + \alpha_8 \text{ PC\_Activation\_Number} + \alpha_9 \text{ Group\_ID\_FEs} + \alpha_{10} \text{ Hour\_of\_day\_FEs} + \alpha_{11} \text{Day\_of\_week\_FEs} + \alpha_{12} \text{ Month\_of\_year\_FEs} + \alpha_{13} \text{ AMPDS\_code\_FEs} + \alpha_{14} \text{ LAS\_Category\_FEs} + \alpha_{15} \text{ Hospital Code\_FEs} + \epsilon$$

Driving to the hospital is also a fairly simple and standardized job. One of the crew members takes the shortest distance and drives to the scene while the other crew member is monitoring the patient. In section 6.2.3, our focus is on the drive to hospital time as an outcome variable (see column 4 in table 4.1). From the results, with a positive coefficient of *Post_one_CI*, it is evident that the crew takes 0.11 minutes longer to drive. And *Post_two_CI*, the crew takes 0.11 minutes longer to drive. There is no effect of one CIs building on one another evident here. The average time to drive to a hospital for regular activations is 13.4 minutes. Hence, following a CI, the crew takes 0.9% more time to drive to the hospital. When compared to the cycle time, this effect is slightly smaller. This supports the hypothesis H2C.

6.2.4. CIs and work performance at the hospital:

$$\text{Hospital\_time} = \alpha_1 + \alpha_2 \text{ Post\_one\_CI} + \alpha_3 \text{ Post\_two\_CI} + \alpha_4 \text{ Critical\_Incident} + \alpha_5 \text{ Shift\_Utilization} + \alpha_6 \text{ Time\_Since\_Start} + \alpha_7 \text{ Activation\_Number} + \alpha_8 \text{ PC\_Activation\_Number} + \alpha_9 \text{ Group\_ID\_FEs} + \alpha_{10} \text{ Hour\_of\_day\_FEs} + \alpha_{11} \text{ Day\_of\_week\_FEs} + \alpha_{12} \text{ Month\_of\_year\_FEs} + \alpha_{13} \text{ AMPDS\_code\_FEs} + \alpha_{14} \text{ LAS\_Category\_FEs} + \alpha_{15} \text{ Hospital Code\_FEs} + \epsilon$$

Patient handover time, termed as total turnaround time at the hospital, is a standardized task. The hospital staff also drive some of the work as they interact with the crew. Hence this task is not as stressing as others. In section 6.2.4, our focus is on the *Hospital_time* as an outcome variable (see column 5 in table 6.1). From the results, with a positive coefficient of *Post_one_CI*, it is evident that the crew takes 0.03 minutes longer at the hospital. And *Post_two_CI*, the crew takes 0.01 minutes longer at the hospital. The average time at the hospital for regular activations is 15.6 minutes. Hence, following a CI, the crew takes 0.2% more time at the scene. When compared to the cycle time, this effect is very insignificant. This regression result is also

not very significant. It could be because of some gaps in the data. This supports the hypothesis H2D.

6.2.5. CIs and work performance during the preparation time:

$$Preparation\_time = \alpha_1 + \alpha_2 \ Post\_one\_CI + \alpha_3 \ Post\_two\_CI + \alpha_4 \ Critical\_Incident +$$
$$\alpha_5 \ Shift\_Utilization + \alpha_6 \ Time\_Since\_Start + \alpha_7 \ Activation\_Number +$$
$$\alpha_8 \ PC\_Activation\_Number + \alpha_9 \ Group\_ID\_FEs + \alpha_{10} \ Hour\_of\_day\_FEs +$$
$$\alpha_{11} \ Day\_of\_week\_FEs + \alpha_{12} \ Month\_of\_year\_FEs + \alpha_{13} \ AMPDS\_code\_FEs +$$
$$\alpha_{14} \ LAS\_Category\_FEs + \alpha_{15} \ Hospital \ Code\_FEs + \epsilon$$

Preparing an ambulance after an activation is discussed in 3.2.5. Since this task is not as complex as other tasks, the crew may take some time before it goes green. In this section, our focus is on the *Preparation_time* as an outcome variable (see column 6 in table 4.1). From the results, with a positive coefficient of *Post_one_CI*, it is evident that the crew takes 0.05 minutes preparing the ambulance. And *Post_two_CI*, the crew takes 0.32 minutes longer preparing the ambulance. The average time at the hospital for regular activations is 14.8 minutes. Hence, following a CI, the crew takes 0.3% more. However, this effect is even more significant after the second CI during the shift. The CI takes 3.2% more time preparing the ambulance after two CIs. This indicates that the crew is distressed and might slow down before they resume work. This effect is more than double the effect on the total cycle time. This supports the hypothesis H2E.

Hence, from the results in column 2-6 of table 6.1, it is evident that while a CI negatively affects Paramedic work performance, the effect is not similar for all tasks. More complex tasks have a more significant effect and this result proves our second hypothesis H2.

6.3.   ROBUSTNESS ANALYSIS

In this section, we study the robustness of our results as we change the definition of the key predictor of the outcome variable itself. Since the analysis pivots around CIs, the effect should be robust for as long as the incident is serious, threatening and possibly distressing. Hence, we experiment with some CI definitions as discussed in section 3.2. In addition to the base

definition for CIs as blue calls, we also derived results for other definitions of CIs as tabulated below:

Table 6.2 Types of CIs

CI	No. of Activations
Blue call	44,578
Blue call with a child (Patient age <12)	2,995
Blue call and Alcohol related	1,017
Blue call and Assault	1,443
AMPDS category D or E (near death cases) and Child (Patient age <12)	28,973
Assault and Alcohol	7058

Table 6.3 OLS coefficient estimates for regressions with different CI definitions

	Bluecall	Bluecall+child	Bluecall+alcohol	Bluecall+assault	AMPDS D/E	AMPDS D/E+child	Assault + Alcohol
Post_one_CI	0.740***	0.41	2.548*	0.75	0.665***	0.842***	1.05
	(0.13)	(0.54)	(1.06)	(0.83)	(0.1)	(0.15)	(0.82)
Post_two_CI	1.119***	1.80	10.56	0.43	0.15	0.29	3.26
	(0.25)	(2.57)	(8.4)	(5.32)	(0.13)	(0.33)	(5.04)
R-sqr	0.35	0.40	0.47	0.45	0.28	0.32	0.43
N	185713	15307	5200	7481	335855	137159	7058

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Each person reacts to an incident differently depending on their experiences, personality and the seriousness of the incident. However, as part of this research, we define certain serious medical cases as CIs. The main results were derived assuming CI are blue calls. As part of this section, for robustness check, we change the definition of CI as per Table 6.2 and present the results in table 6.3 for cycle time using same specifications from section 6.1. Column 1 is blue call and Columns 2-6 are the definitions as listed in table 6.2. Since the effect depends on the reaction of the individual, some of these results are not very significant.

All the coefficients for *Post_one_CI* from columns 1-6 are positive indicating that following a CI, the cycle times increase. For example, post an AMPDS category D or E case, the crew takes 0.7 minutes longer to finish one activation which is 0.9% longer than the average time per operation. Post an AMPDS category D or E incident with a child, the crew takes 0.8 minutes longer to finish one activation. The results hence support the hypothesis H1. While the magnitude of the effect is relatively small, this effect builds on previous stress and magnifies and as discussed in the literature review, it can be presage to long term effects of PTSD.

7.   CONCLUSION

In this thesis, we study the impact of CIs on operational performance. We also study the level of impact of CIs for various sub-tasks to see if the impact increases as the complexity of the task increases. We find that the results support the hypothesis developed in the research and from the robustness analysis in section 6.3, it can be concluded that following a CI, the crew takes longer than the average time to finish the task, although the magnitude of the effect depends on the complexity of the task involved, hence performance is negatively affected following a CI.

This research work has some limitations. First, each person reacts differently to different situations. What might be traumatic to one person might not be so serious for someone else. This depends on (for example) the life and work experiences, personality and attitude and incident type. Since the definition of CIs in this research is an assumption, specific theory on CI definitions would allow more analysis. Second, given the scope of the data, performance is measured only in task completion times. There may be further metrics to measure performance like quality of care and number errors.

There is scope to take this research forward by attempting to answer some follow up questions that could not be addressed in this thesis. First, how persistent is the negative impact of CI? Is there a "cool off" time period after which the impact of CI subsides? While there is some evidence that CIs can have a long-term impact on emotional wellbeing, we expect the effect of a single CI to diminish with time. Second, are there any operational measures which can be taken following CIs to mitigate their effects on subsequent performance? Specifically, we could consider three mitigation strategies. Potentially longer breaks or idle time following a CI can reduce the size of the impact on subsequent performance. Or, there may be heterogeneous effects by the complexity of subsequent tasks; i.e., workers who are assigned less complex tasks following a CI may recover more quickly than those who repeatedly

encounter challenging situations. Pairing workers with those having more experience may also help them cope and revert to normal performance more quickly.

The importance of this research is that organizations could amend managerial policies and practices about recognizing and managing stress and institute better training practices. Downtime after CIs is linked to reduced association with negative psychological impacts and hence fewer PTSD possibilities. This translates to better work performance for organizations. Halpern et al. (2014) indicate that organizations may recognize the importance of downtime and give employees rest time ranging from 30 minutes to the end of shift for better employee health and improved work performance. Also, from J. Gaab et al. 2003, the deleterious outcomes of stress induced neuroendocrine stimulation can be prevented by stress management training J. (Gaab et al. 2003, McCue and Sachs, 1991) and counselling. As more and more organizations understand the significance of this matter, better systems can be put into place.

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