Prehospital Point-of-Care Testing in the United Arab Emirates: Capnography and related diagnostic capability among Emergency Medical Technicians-Basic

By

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Key Words and Common Abbreviations

Diagnostic Capability:(Diagnostic in the medical sense) “a device or substance used for the analysis or detection of diseases or other medical conditions” (Dictionary.com, 2020). In this study the Diagnostic Capability refers to the EMT-Bs ability to process information received from such a device.

Emergency Medical Technician: Basic (EMT-B): This cadre of emergency care worker should be able to perform basic clinical assessments and interventions to stabilize a patient and maintain life in an emergency situation. The EMT-B practitioners are trained by an (accredited or licenced) training provider and licensed with the Health Authority Abu Dhabi at a Basic Life Support level with a specified scope of practice. Note that EMT-B is a professional title and is not intended in process or outcome to objectify people occupying such a role.

Point-of-Care Test (POCT): The College of American Pathologists defines POCT as “testing that is performed near or at the site of a patient with the result leading to a possible change in the care of the patient.” (Joint Commission International, 2019). “Point-of-care” and “point of care” will be used interchangeably.

End-tidal CO_2 ($ETCO_2$): monitoring is a non-invasive technique which measures the partial pressure or maximal concentration of carbon dioxide (CO_2) at the end of an exhaled breath, which is expressed as a percentage of CO_2 or in units of millimetres of mercury (mmHg). The normal values are 5% to 6% CO_2, which is equivalent to 35-45 mmHg (Office, 2018).

Capnography: Capnography is the monitoring of the concentration or partial pressure of carbon dioxide (CO_2) in the respiratory gases. It is presented as a graph of expiratory CO_2 (Office, 2018).

UAE: the Country of United Arab Emirates (UAE), a federation of seven emirates in the east coast of the Arabian peninsula (Britannica Encyclopedia, 2021).

TBI: refers Traumatic Brain Injury. TBI has been broadly classified as either mild, moderate, or severe. Part of this definition is based on the 15-point, modified Glasgow Coma Score (GCS), which has been used to assess neurologic condition after a head injury (Otten and Dorlac, 2017).

CPR: CPR stands for cardiopulmonary resuscitation. It is an emergency life-saving procedure that is done when someone's breathing or heartbeat has stopped. This may happen after an electric shock, heart attack, or drowning. CPR combines rescue breathing and chest compressions. Rescue breathing provides oxygen to the person's lungs. Chest compressions keep oxygen-rich blood flowing until the heartbeat and breathing can be restored (US National Library of Medicine, 2013).

SGAs: Supraglottic airways (SGAs) are a group of airway devices that can be inserted into the pharynx to allow ventilation, oxygenation, and administration of anaesthetic gases, without the need for endotracheal intubation (Almeida, 2016).

ROSC: Refers to the return of spontaneous circulation (following a cardiac arrest). Signs of the return of spontaneous circulation (ROSC) include breathing (more than an occasional gasp), coughing, or movement. For healthcare personnel, signs of ROSC also may include evidence of a palpable pulse or a measurable blood pressure (Jacobs, *et al.*, 2004).

ACLS: Refers to Advanced Life Support (ACLS) Course that is registered with the American Heart Association® (AHA). The AHA's ACLS course builds on the foundation of lifesaving BLS skills, emphasizing the importance of continuous, high-quality CPR. Reflects science and education from the American Heart Association Guidelines Update for CPR and Emergency Cardiovascular Care (ECC) (American Heart Association, no date)

PALS: Refers to the Paediatric Advanced Life Support (PALS) Course that is registered with the American Heart Association® (AHA) (Topjian, *et al.*, 2020)

PHTLS: Refers to the Prehospital Trauma Life Support (PHTLS) Course. The mission of PHTLS is to promote excellence in trauma patient management by all providers involved in the delivery of prehospital care. PHTLS is developed by NAEMT in cooperation with the American College of Surgeons' Committee on Trauma. The Committee provides the medical direction and content oversight for the PHTLS program (Pollak, 2020).

EMS: Refers to Emergency Medical Services (EMS) that operate Ambulance and Emergency Medical Services in a system. By definition an EMS system is any specific arrangement of emergency medical personnel, equipment, and supplies designed to function in a coordinated fashion. May be local, regional, State, or national (National Highway Traffic Administratrion (NHTA), no date)

Contents

Abstract

Problem and Purpose

Ambulance personnel with Emergency Medical Technician-Basic (EMT-B) qualifications employed by National Ambulance Service in the UAE have access to capnography to aid clinical decision-making. It is unconventional for EMT-Bs to use capnography for clinical monitoring. There is little evidence on the use $ETCO_2$/capnography as a Point-of-Care Test (POCT) at EMT-B level of care. There is no research to show the clinical value proposition and self-perceived value of this scope addition to EMT-B providers, nor has the skill transfer been evaluated. The problem of 'How does point-of-care testing through capnography, enhance (or complicates) the diagnostic capability of EMT-Bs in the UAE?' is posited in this study.

Methods

A post-positivist paradigm with a deductive analytical approach was used. The literature review informed the problem description and factor analysis, followed by the analysis of retrospective quantitative data from archived patient records. The EMS database produced an epidemiological description of $ETCO_2$ practice over a 12-month period, with 39 937 patient care records of potential and actual capnography utilization. The prospective survey of 281 EMT-Bs informed the self-perceptions on $ETCO_2$ and related diagnostic experience of EMT-Bs in the northern emirates of the UAE.

Results

In the retrospective data collected from Patient Care Records (PCR), the high caseloads observed in the Sharjah Emirate compared to other emirates drew attention to the maldistributed caseload and the geographical bias of capnography exposure to cases *(p-value*: $1.17x10^{-12}$). $ETCO_2$ utilization by EMT-Bs caring for Head and neck injuries showed 1.65% use, Breathing difficulty: 19.88%, Trauma/Assault cases: 2.73%, Mental/Emotional and Psychological cases: 2.09%, and the other case categories were at 4.52% utilization. $ETCO_2$ was used on 52.2% of the resuscitation cases and among those CPR cases that had airway adjuncts in-situ, 54.77% of them were monitored with $ETCO_2$ (*p-value*: 5.23×10^{-5}). In CPR cases, 62.04% ROSC was observed with $ETCO_2$ use (p-value: 0.0398). The 0-10 mmHg category of $ETCO_2$ has the greatest escalation trend in more than 1500 cases. Trends in monitoring of patient respiration rates beyond normal parameters (10-20 breaths per minute) using capnography highlight appropriateness of use; also seen with assessments of Asthma patients (27.68%, n = 49), assisted ventilation (49.34%, n = 113) in resuscitation cases and in non-resuscitation cases (3.78%, n = 1470). The mean shock index was lower among $ETCO_2$ patients (*p-value*: 2.1115793×10^{-98}).

The results of EMT-Bs perceptions of capnography use in the survey, highlighted that 89.7% (n = 252), still used conventional observing of chest excursions and 85.8% (n = 241) included the use of stethoscope. Although a majority (78.3%; n = 220) reported using capnography in assessing

patient ventilations, utilization of $ETCO_2$ was used in only 4.98% (n = 1987) of cases. Proportions of respondents that perceived positive value in capnography use were in relation to: placement of SGAs (78.9%, n = 202), guiding ventilation (93.3%, n = 237), managing traumatic brain injury (93.8%, n = 240), monitoring CPR quality (97.2%, n = 249) and as a predictor of CPR event outcome (94.5%, n = 241). The EMT-Bs that found value in monitoring spontaneous breathing of alert patients, was at 65.6% (n = 168) and 87.9% (n = 225) considered capnography as useful in observing Covid-19 patients. Most (66.8%; n = 171) perceived capnography as being useful in detecting ROSC, and 61.3% (n = 157) correctly identified hypoventilation in a brain injury scenario. Diagnostic detection of broncho-constriction by some EMT-Bs (44.1%; n = 113) and diagnostic value of CPR adequacy were not well interpreted. Capnography was easy to set-up and use, was the majority view (93.3%; n, 236) and 74% (n = 188) felt that capnography enhanced their ability. No patient gender bias detected in capnography use (*p-value*:0.906) and education and training were perceived as the overall greatest need for capnography use by 80.1% (n = 225) of respondents.

Conclusion and Recommendations

EMT-Bs operating in the northern emirates of UAE have demonstrated the use of capnography as a tool to support their diagnostic abilities. Capnography use has been low but safe, notwithstanding that it is not normally a scope expectation for EMT-Bs. The study documents the need for education and training support to create an enabling environment for adoption of new technologies. Risk mitigation may be managed through quality and audit systems. The inclusion of capnography into the EMT-B scope of practice has favorable implementation and user acceptability. Patient outcomes in such an initiative warrants additional research. New technologies and advancements in artificial intelligence requires EMS to promote technical relevance, including capnography optimization among frontline health care workers.

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Chapter 1 – Introduction to the study

1.1 Introduction

The study focuses on the Emergency Medical Technician-Basic (EMT-Bs) personnel employed by the National Ambulance (NA) to provide basic life support in outlying areas of United Arab Emirates (UAE), where they respond to emergencies, provide emergency care and transportation to patients. Given the environmental factors and pressures associated with the emergency setting, these clinicians are required to diagnose and treat patients with optimal care. To this end the EMT-Bs need good diagnostic skills and support. Although, foundational education and training prepare the EMT-Bs with basic subjective diagnostic skills, some recommended Point-of-Care Tests (POCT) can provide objective data to appraise severity and/or improvement in patient care. Conventional tools used in the prehospital Emergency Medical Service (EMS) setting have always been available for assessing patients however, currently the EMT-Bs have the benefit of capnography, which is the end-tidal monitoring of partial pressure of carbon dioxide ($ETCO_2$) to support their diagnostic abilities. Therefore, this multi-phase observational study intends to: a) provide an epidemiological description (Phase 2) of $ETCO_2$ use by EMT-Bs in the field and b) document the basic EMTs self-perception (Phase 3) of the inclusion of $ETCO_2$ into their clinical practice. The information derived from the study will likely be of value to inform the continuous quality improvement of patient care at EMT-B level, and to also highlight new standards of care that can support these cadres in decision-making in the emergency setting. Information on implementation of$ETCO_2$, as a POCT, can also be used to inform other EMS systems that wish to embark on such endeavours in capacitating staff in the midst of scarce skills and high acuity patients in remote settings.

1.2. Background

National Ambulance is a pre-hospital EMS provider in the UAE. The organization was established to serve the public through a government mandate without excluding private clients, and commenced operations in the year 2010. Being a government operated entity, National Ambulance is mandated to provide emergency medical services (at EMT-B level) in the northern fives (5) emirates of the UAE, which is not as developed as the remaining two (2) metropoles in the south, Dubai and Abu Dhabi Emirates. National Ambulance is a recognised EMS provider for and on behalf of government in the northern emirates. The EMT-Bs operating in northern geographical location, are employed almost exclusively by National Ambulance and may be considered a fair representation of pre-hospital EMT-Bs working in those emirates. The EMT-B clinical staff operating within National Ambulance operations possess a primary nursing degree,

in addition to an Emergency Medical Technician (EMT) qualification with a minimum of two (2) years of post-qualification exposure to the EMS operations as an entry requirement. Prior to any deployment into the operational arena, the EMTs register with local health regulatory authorities at a basic life support level (EMT-B) and are supported with Induction/On-boarding Programmes designed by National Ambulance to integrate EMT-Bs into the middle-eastern EMS operations. Subsequent endeavours to bridge the gap in clinical needs for outlying areas where there is limited out-of-hospital clinical support culminated in some skill shifting. The intentions were to be able to provide a more comprehensive range of care through targeted resuscitation programme, supporting skills that EMT-Bs may have limited exposure to in the EMS setting.

Skills enhancement included intravenous fluid administration, advancements in cardio-pulmonary resuscitation (CPR) practices and some pharmacological therapies that were phased-in to the EMT-B's clinical scope. Capnography/$ETCO_2$ use as a point-of-care-test (POCT) was also added to the new practice, given their advocacy in recommended resuscitation guidelines (AHA, 2015) practices. Specific exposure through Advanced Cardiac Life Support (ACLS) and Paediatric Advanced Life Support (PALS) programmes given their nursing degree qualification made them eligible to attend such advanced courses. Other, in-house programmes such as the On-boarding Programmes, Basic Airway Course and Advanced Airway Courses also exposed the EMT-Bs to capnography knowledge and practice. Further, programmes such as the Prehospital Trauma Life Support (PHTLS) also encouraged the use of capnography in the management of patients especially with Head Injury patients. However, the pre-hospital EMT-B practitioner level of qualification mandated to use capnography was not stipulated. National Ambulance EMT-Bs have access to capnography and they make use of it but, the trends of use or value of this POCT has not been assessed. To date, there is no research to show the value proposition, self-perceived value or operational beneficence of this scope addition to EMT-B providers, nor has the skill transfer been evaluated.

In the out-of-hospital setting, EMT-Bs make up the majority (91%, n = 438) of the workforce providing frontline clinical care at National Ambulance. EMT-Bs generally are exposed to basic education and training, yet they are expected to recognise and manage patient's life-threatening conditions such as shock, respiratory compromise, head injuries or patients in cardiac arrest.

The EMT-B population employed at National Ambulance that is included in the study are almost entirely of the Filipino nationality. They have studied in their home country (Philippines) and attained the relevant qualification and clinical experience before relocating to work in the UAE. The significance of the nationality mention is due to standard of the EMT qualification, is regulated by the Emergency Medical Services Systems Act 56 of 2009 (Philipines, 2009) and the National Registry of Emergency Medical Technicians (NREMT) from the United States of America (USA) is a recognised curriculum that meets the needs of the EMT-B qualification for licensure in

the Philippines. The EMT-B course being an internationally recognised programme, is also accepted in the UAE. However, for licensure in the UAE, cognitive and psychomotor competency tests are still required for a local Health Authority License to be issued, before practice in the UAE is permitted (DOH Abu Dhabi, 2017).

Independent clinical practice for all levels of EMTs in the UAE is not permitted. All Emergency Medical Technicians (irrespective of level of qualification) must provide patient care under the guidance of a registered health organisations Medical Director. Therefore, at National Ambulance all clinical staff are assessed and privileged for clinical practice based on education, certification, credentialing and licensure levels (Ayman, 2019). The Emergency Medical Technician–Basic (EMT-B) level is the minimum licensure level standard for personnel transporting patients in ambulances in the UAE (Government of UAE, 2017).

The scope of practice of an EMT-B is limited to basic skills that can be safely and effectively performed in the prehospital setting with basic training and strict adherence to clinical guidelines. The National Registry of Emergency Medical Technicians (NREMT - the statutory body that regulate the EMT education standards) in the US, acknowledges that the EMT-B are not trained to make decisions on the patient's disposition, on their own. The psychomotor skills set includes airway and breathing assessment and interventions, basic pharmacology interventions and trauma care (Samuels, 1992). Although support ventilation is included as part of breathing, $ETCO_2$ is not stipulated within the scope of EMT-Bs. In the National Standard Curriculum for EMT-Bs under the auspices of NHTA, the course content was redefined and standardised in 1990 (Samuels, 1992). In the United States the nationally accepted EMT-B programme of one-hundred-and-ten (110) instructional hours duration includes the content of preparatory subjects, airway management, patient assessments, trauma and medical pathologies including care. The programme also extends to infant, children and operational contents as well (Samuels, 1992). It is noted that in the curriculum, cognitive, affective, psychomotor objectives for vital sign monitoring as well as airway and ventilation components do cover the respiration evaluation and support mechanisms however, no specified method of monitoring for these assessments or interventions are mentioned. The EMT-B Scope of practice is highlighted in the National Ambulance Policy that deals with the EMT's Fitness to Practice Policy (Cummins, 2016) and the National Ambulance Policy for Extended Scope Practice (Ayman, 2019).

EMT-B level clinical staff at National Ambulance in the UAE have access to sphygmomanometers, pulse oximetry, temperature monitors, blood-glucose tests, ECG monitors and even capnography to support their clinical decision making. While most of these tools have been in existence for many decades in the EMS systems, there seems to be little information on $ETCO_2$ /capnography as a POCT, especially at EMT-B levels of care. Clinical education, tools available (including Point-of-care Tests) as well as operational systems, can help support clinical decision making based on

objective parameters and subjective assessment (Price, 2017). Therefore, this study intends to focus on the newer adjuncts (such as capnography) that may lend additional support for or confound critical interventions at an EMT-B level of clinical care. Further, the EMT-B perceptions of the adjunctive POCT tools implementation, use and value, is worthy of analysis in the interest of implementation science and evidence-informed health care practice.

1.3. Statement of the Problem

How does the point-of-care testing (POCT) through capnography, enhance (or complicates) the diagnostic capability of EMT-Bs in the UAE?

1.4. Purpose of the Study

This study intends to address the gaps in the knowledge of how the diagnostic capability of EMT-Bs may be altered by the enhancement of POCT capnography, as well as the perceived value of the diagnostic tool given the exposure. In the context of EMT-Bs scope of practice (Ayman, 2019) operating in the UAE, the relationship between POCT capnography and diagnostic capability is undocumented in this population. Such knowledge could inform how enabling[1] or burdening[2] scope changes can be for EMT-Bs. That the focus of this observational study (due to limited study scope) will focus on airway, breathing and some circulatory considerations, nuances the study relevance. $ETCO_2$ may be useful as an indicator of airway patency, breathing and ventilation statuses as well as an indicator of shock and particularly useful in assessment of circulation in resuscitation cases (Aminiahidashti, *et al.*, 2018). In-line with PICO[3] principles, the problem statement encompasses the problem, intervention, comparison and outcomes ''How does the point of care testing (POCT) through capnography, enhance the diagnostic capability (or burdening) of EMT-Bs in the UAE?'' The intervention (capnography as a POCT tool) entails a study to determine the current utilization trends in terms of the uptake of the enhanced practice, together with perceptions of the EMT-Bs on the inclusion of capnography in their clinical scope. The comparison between capnography serving to enhance EMT-Bs diagnostic ability versus

[1] Enabling, referring to capnography as a POCT tool use that can positively support (help) EMT-Bs with quick and accurate measures of $ETCO_2$ that will aid swift and confident decision making.

[2] Burdening (converse to enabling), refers to capnography as a POCT tool that hinders or distracts EMT-Bs from clinical decision making, with negative impact (less accurate decision making) and can be considered adding unwarranted stress to the clinician.

[3] PICO: The PICO (population, intervention, control, and outcomes) format is a widely known strategy for framing a "foreground" research question. Breaking the question into four components will facilitate the identification of relevant information.

capnography being a hindrance or distraction in clinical decision making. Lastly, the outcomes the study informs the current impact of capnography on EMT-Bs in the UAE. These may also indirectly inform, quality and efficiency of EMT-Bs practice, while also supporting this group in aligning with emerging trends of clinical best practice. The outcome of the study may also have implication in highlighting task shifting in EMS Systems, if anything.

This study is about point-of-care testing (POCT) focused on capnography. We have learnt from the review of the literature, that with the advent of technology, that capnography as with other POCT tools, are becoming more accessible, and that future practice will be led by these technological innovations (Basis, 2009). It is also understood that the EMT-B level of 'Ambulance Workers' practice at a basic level of care, given their limited training and scope of practice (National Highway Traffic Administration (Samuels, 1992; DOH Abu Dhabi, 2020). Combining advances in technology and enhanced practice begs the question: "How does the point of care testing (capnography) affect the diagnostic capability and clinical scope of Basic EMTs in the UAE?" The perceptions of the EMT-Bs that have exposure to the enhanced POCT Capnography can help answer these questions from first hand experiences in practice. In terms of these developments in a changing scope, we need to then interrogate the implications and ask: What do these changes mean for EMT-B practice?

1.5. Research Aim

To document how does point-of-care testing (POCT) through capnography, enhance (or complicates) the diagnostic capability of EMT-Bs in the UAE.

1.6. Objectives

1.6.1. To Provide an epidemiological description of $ETCO_2$ application by EMT-Bs.

The historical data, demographic trends, of the EMS records of clinical pathologies associated with $ETCO_2$ application, provide an epidemiological description of capnography in the context of interest.

1.6.2. To document the Basic EMTs self-perception of the inclusion of $ETCO_2$ into their clinical scope.

The most critical of stakeholders in any scope enhancement is likely to be the care-givers who endure new expectations for performance of clinical care. An understanding of their experiences and perceptions related to capnography are crucial for prehospital capnography to be made sustainable and safe in application.

1.6.3. To provide context to task shifting in settings of greater need than resources availability, while exploring opportunity versus risk benefits.

1.7. Secondary Questions:

1.7.1. What is the exposure rate and diagnostic value of out-of-hospital capnography for EMT-Bs in the UAE?

The actions taken by EMT-Bs in operations (post training) speaks to the exposure rate and diagnostic value that EMT-Bs gained in the process. Answers may be derived from the trend analysis of $ETCO_2$ use (Willmott and Arrowsmith, 2013).

1.7.2. What is the self-reported experience and perception of the scope inclusion of capnography by EMT-Bs in the UAE? In an attempt to answer this question, parameters of education and training, experience, associated tools availability, support, diagnostic ability, safety etc. may have to be analysed.

1.7.3. Notwithstanding the cost-benefit of not employing higher levels of care, what opportunity are there in relation to practitioner risk or patient safety? However, this may be limited to what is documented and not necessarily what patient outcomes are.

1.8. Significance of the Study

To appreciate the significance of the research, the following three questions provide insight:

1.8.1. Study purpose: This study is about Point-of-Care Testing focused on Capnography. We have learnt from the literature reviews that with the advent of technology, capnography, as with other POCT tools is more accessible, and that future practice will be led by these types of innovations (Basis, 2009). It is also understood that the EMT-B level of ambulance staff practice at a basic level of care, given their limited scope of practice and training (National Highway Traffic Administration (NHTA, no date; DOH Abu Dhabi, 2020). Therefore, combining advances in technology and enhanced practice begs the question: "How does the point of care testing (capnography) affect the diagnostic capability and clinical scope of Basic EMTs in the UAE?" The perceptions of the EMT-Bs that have exposure to the enhanced POCT capnography can help answer these questions from first hand experiences in practice. To interrogate the implications, what did these changes mean for EMT-B practice?

1.8.2. Relevance: Of what relevance might the findings be? In enhanced practice, safety and sustainability are always of concern. The current utilization trends in terms of the uptake of the

enhanced of practice together with perception of the EMT-Bs may lead to better understanding of and strengths or weaknesses. These in turn may be used to identify safe practice as well as enablers that can ensure sustainability before being considered for use in a wider population and this brings attention to what the next course of action should be.

1.8.3. Significance: What contribution might the newly acquired information make? Given the limitations in health resources world-wide, task shifting is well recognised as a process in helping deal with health needs. Therefore, using the information gained from the study may help enabling EMT-Bs and supporting them further (if required) to use POCT tools like capnography for enhanced practice.

The overall implications of the study may serve to increase in quality and efficiency while also supporting this workforce to align with clinical best practice. Further, the re-consideration of the EMT-B scope of practice may help to change mind-sets in terms of EMT-B practice clinical roles. The outcome of the study may even have implications for setting of new trends in EMS systems (DOH Abu Dhabi, 2020) or for critiquing the normative allocation of clinical and diagnostic skill.

1.9. Research Design

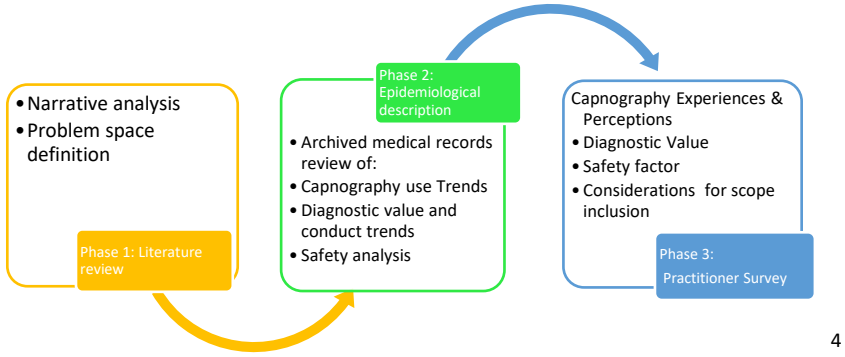
A post-positivist paradigm using a deductive approach is the design adopted for this study. Data of an empirical (quantitative) nature was collected and analysed retrospectively (Phase 2). For the initial parts of the study, electronic data captured on an EMS database was mined to extract details required to analyse and report on an epidemiological description of $ETCO_2$ practice by EMT-Bs in the northern emirates. A subsequent practitioner survey (Phase 3) was used to extrapolate perceptions and diagnostic values (Figure 1) of capnography (at an EMT-Basic level of practice).

The empirical data retrieved from processes mentioned, needed to be put into perspective. Factors such as the local cultural, ethical and political influences in the Middle East that may be very different to the western world were considered and is reported on, for context. The post-positivist paradigm allowed flexibility for this type of consideration to contextualise the study observations.

1.9.1 Research Method:

Phase 1, involved a literature review. An extensive narrative analysis explicated the factors associated with POCT capnography, and prehospital diagnostic practice. The literature review informed the problem description and factor analysis to be considered. In the second phase, a

review of electronic patient care records was conducted to determine the quantitative trends of capnography utilisation, albeit retrospectively. Understanding capnography practice from medico-legal records informed the survey parameters and also provides insight of the EMT-Bs past practice trends using $ETCO_2$. Phase 3 involved using a prospective, descriptive, online survey, to attain quantitative data on capnography experiences and perception of the EMT-Bs in using $ETCO_2$ to support their diagnostic skills. The survey questions were informed by the Phase 2 findings. This methodological addition aligns to other studies of a similar nature (Wylie, *et al.,* 2019). Figure 1 summarizes the methods.



[4]

Figure 1: Three sequential phases of the study.

1.9.2. Research Process Information

A recent study titled: 'Waveform capnography in the South African prehospital setting: assessment of qualified advanced life support paramedics in the pre-hospital use of capnography' was used in informing the current study design and methodology (Wylie, *et al*., 2016). Interestingly, even at Advanced Life Support (ALS) level of practice, there were reported problems experienced with capnography use. The need for improved education and exposure was highlighted in the study (Wylie, *et al*., 2016), although it did not consider BLS practice in any part of the study.

The Wylie, *et al*. study population comprised of quantitative data from 60 Advanced Level Practitioners (EMT-A) from a private ambulance service in South Africa. This study was limited, in that it was not representative of the larger EMS community and was therefore, not generalizable. An electronic survey in the form of a questionnaire was used as the preferred tool for data collection and was effective in retrieving the required empirical detail and had relevance to the study design.

[4] Research Method Sequential Phases: Created to highlight process.

The questionnaire instrument was considered appropriate but the structure and content had to be modified after the analysis of the medical records. The structural adaptations of the survey warranted pilot testing of its suitability in retrieving the required fields of data to meet the objectives of the study. In this instance the Post-Positivist paradigm coheres well. The contextual factors were intended to provide an understanding of patient care confounders prevalent in the middle-east. Also, the study looked at the utilization trends in a much larger sample (that was representative of the geographical area) and was intended to identify clinical bias, education gaps and other variables envisaged in the objectives.

1.9.3. Study and sample population:

Phase 2: A twelve (12) month review spanning a fiscal year (March 2019 to February 2020) review of 39 937 Patient Care Records (PCRs) records from an EMS (National Ambulance) electronic database that documented potential or actual capnography use (Annexure I).

Phase 3: All Operational EMT-B providers (approximately n = 438)[5] based in the Northern parts of UAE where National Ambulance is the primary provider of prehospital emergency medical care was invited to participate in the survey. Using the formula[6] below, a sample size of 250 was estimated to provide a confidence level of 95% and a margin of error of 5% for a population size of 438.

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

Figure 2: Sample size calculation

1.10. Assumptions

The following fundamental assumptions predicate the study:

1.10.1. That EMS provides frontline emergency medical services with the use of ambulances, regionally standardised medical equipment and qualified emergency medical staff.

[5] Approximately n = 438: approximate is used due to the availability of EMT-Bs changing frequently. The exact number at the time of the survey may vary according to leave schedules, reallocation of staff, resignations etc.
[5] The sample size calculator is available at: https://www.surveymonkey.com/mp/sample-size-calculator/
Key:
n is the sample size, z is the z-score associated with a level of confidence, p is the sample proportion, expressed as a decimal, e is the margin of error, expressed as a decimal, N is the population size.
Ref. https://goodcalculators.com/sample-size-calculator/ (© 2015-2020 goodcalculators.com)

1.10.2. That Emergency Medical Technicians at Basic Life Support Level (EMT-B) is a recognised medical qualification which allows for guided medical practice at a basic level of care.

1.10.3. That all participants in the survey have an interest in promoting quality in the profession and will have responded honestly.

1.10.4. That irrespective of qualification and experience, all EMTs treat patients to their (perceived) best of their abilities and with the best intent.

1.10.5. The EMT-Bs that have been provided with capnography tools in their ambulances, clinical managers and the patient community have a common expectation of or interest in using these tools as a point-of-care test (POCT).

1.11. Limitations/Delimitations

The study limitations and corresponding delimitations are considered below:

1.11.1. Legal limitations: This study was limited to clinical practice of Emergency Care Technicians – Basic (EMT-Bs) Level (licensed practitioners) in the UAE.

1.11.2. Limitations of setting: The point of care testing tool use assessed in the study is $ETCO_2$/Capnography and in this instance is also limited to the out-of-hospital emergency medical care (EMT-Bs operating in an EMS setting) in the UAE.

1.11.3. Population limits: The particular geographical area for the study population is in the Northern parts of United Arab Emirates (UAE) where National ambulance is the sole provider of EMS and potentially all of the operational EMT-Bs were eligible to be enrolled in the study, although participation was voluntary. This enhanced access to participants and has quality implications in the study with entire population recruitment potential.

1.11.4. Limits of location: Emirates of Sharjah, Ajman, Ras-Al-Khaimah, Fujairah & Umm-Al-Quwain. These five (5) of the seven (7) total emirates are less developed and the EMT-Bs are the frontline clinicians with little support available to them on-site and health referral facilities are sparse (Target Area & Population).

1.11.5. Clinical limitations: Clinical Pathology Categories of Head Injuries, Respiratory Pathologies, Cardio-Pulmonary Resuscitation Cases and any other random cases where there was a potential for capnography use was included in the study only. This study has excluded cardiac events, from the identified pathologies where capnography use has been shown to have value. Capnography monitoring related to the cardio-vascular system can be used highlight low cardiac outputs, decreased perfusion, cardiogenic shock, pulmonary embolus and patient response to fluids (etc.) but this study focuses on the EMT-Basic level of care. Other limitations also included

the evaluation of dehydration, electrolyte imbalances, acidosis, respiratory volumes (etc.) due to the study being confined to the basic level of care at EMT-B level in the EMS environment.

1.11.6. The database of emergency calls analysed is limited to cases where there was a potential for $ETCO_2$ use (39 950) and does not reflect the full total case load (+80 000), for the specified time period of 01 March 2019 to 29 February 2020.

1.11.7. The study was limited to historical trend analysis and EMT-Bs perceived value of capnography at their level of practice, and did not analyse patient outcomes with the limited scope.

1.11.6. Inclusion criteria

The following National Ambulance case pathologies recorded in northern emirates was included:

i. Allergic Reactions
ii. Infectious Diseases - (inclusive of Covid-19 Cases)
iii. Breathing Difficulty
iv. Cardiac Arrest
v. Chocking
vi. Diabetes
vii. Environmental & Toxic Exposure
viii. Head & Neck
ix. Mental, Emotional & Psychiatric
x. OD, Poisoning
xi. Seizures
xii. Sick (unknown)/ Other
xiii. Stroke (CVA)
xiv. Unconscious
xv. Paediatrics
xvi. Assault/ Trauma
xvii. Burns
xviii. Drowning / Water Injury
xix. Falls / Accidents / Pain
xx. MVA

Cases where an advanced airway or Supra-glottic airway (SGA) was used in patient care was included for analysis. Cases where support ventilation (BVM) was used in patient care was also included. Medical records where patient care was not initiated were excluded (e.g. Refusal of care or no patient contact was made). It is probable that not all local cultural, ethical, religious factors that may have effect on POCT use and/or patient care were unpacked due to limitations of the methods.

1.11.7. Exclusion Criteria:

1.11.7.1. EMT-Bs that were not involved in clinical frontline practice (e.g. EMT-Bs in Administration roles and Communication Centre Staff etc.)

1.11.7.2. EMT-Bs that were operationally involved but were currently out-of-country or on leave may not be accessible and therefore were excluded.

1.11.7.3. Operational EMT-Bs that were posted out of the geographical area of study.

1.11.7.4. Clinical pathology conditions where capnography use may be of limited value have been excluded.

1.11.7.5. In cases of respiratory pathology, varying ventilation rates, cardio-pulmonary resuscitation (CPR), head injury, shock, trauma and many other conditions that are related to respiratory compromise, $ETCO_2$ and capnography use has been acknowledged as important indicators to help assess and/or manage care for patients with these afflictions (Basis, 2009; Kodali, 2013). Therefore, pathologies that were not directly related to the respiratory, cardiac, head injury or other areas where $ETCO_2$ value was not highlighted for use, these were not included in this study. One may argue that any of the excluded pathologies may have indirect effects, while this may have some merit, it was not forthcoming in literature reviews. Further, due to the study being limited to Basic Life Support care, just the direct related pathologies were considered for inclusion. Case Pathologies that were excluded from the study dataset were as follows:

i. Abdominal pain
ii. Back Pain
iii. Bleeding (non-trauma related)
iv. Chest Discomfort / Heart Problems
v. Medical Knowledge
vi. Pregnancy/ Childbirth/ Gynaecological
vii. Animal Bites
viii. Standby cases
ix. Deceased
x. No Injury /Illness cases

Patient care records where patient care was not initiated are not included in the dataset. (e.g. refusal of care, where there was no patient contact, or no patient was found, or case was cancelled enroute etc.)

Duplicate patient care records (PCRs) will be excluded. Sometimes two (2) or more ambulances are dispatched to the same case for crew or clinical support.

Hard copy patient care records (PCR) that have not been entered into the database. These are expected to be minimal as a hard copy of the patient care recorded is only completed when the electronic tool used is unavailable or has experienced a technical problem and the electronic entry is made subsequently.

1.12. Summary

The study was intended to be comprehensive and involved significant attention to sampling with the largest data set possible within a one-year period. The streamlining of the objectives and clarity of the structure, compliance to research guidelines and timeous planning, made the study achievable. Having met the required ethical standards by the Cape Peninsula University of Technology Research Ethics Committee[7], Ethics approval was granted on the 16th July 2020 (REC Approval Reference Number: CPUT/HW-REC 2020/H9) Annexure A: CPUT Research Ethics Approval is also attached as reference. Where appropriate the third person personal pronoun was used in the narrative. The leading sections of the study that structures this research comprises six (6) Chapters that follow.

Chapter 1, provides the study overview in terms of the background, problem statement and study objectives. Also included in Chapter 1 was the basis of the study design, structure and the delimitations of the study. Chapter 2 provides a literature review using narrative analysis to highlight information available on $ETCO_2$ and capnography as well as the gaps in knowledge pertaining to the EMS fraternity. Chapter 3 details the study methods quite comprehensively and the related ethical matters. Chapter 4 deals with results obtained from the Phase 2 of the study (Retrospective analysis of the historical trends in $ETCO_2$ use among the EMT-Bs at National Ambulance) as well as the results of Phase 3 of the study (the EMT-B's self-perception of inclusion of $ETCO_2$ into their scope of practice) as well these results interpreted. Chapter 5 comprises of the discussion while Chapter 6 concludes with some recommendations. The study is presented by the principle investigator in third-person past participle pronoun in the research context and where other sources of information has been considered, these have been referenced. The referencing has been constructed through the 'Mendeley Programme' using the recommended Harvard Style referencing format 'Cite Them Right 10th edition – Harvard.'' It is duly noted that this system lists the names of the initial authors in the reference as a standardized format. However, access to all the author names is revealed once the particular reference is accessed.
The structured approach is used to highlight the context, process and outcomes, to uncover information relating to the $ETCO_2$ use, knowledge base and diagnostic value experienced by the

[7] The CPUT REC is duly registered with the Department of Health National Health Research Ethics Council.

participants, as per the objectives of the study of the EMT-Bs in the northern emirates of the UAE.

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Chapter 2 – Review of the Literature

2.1 Introduction

In an attempt to establish what is already known in the areas of pre-hospital care and the role of Point-of-Care-Testing (POCT), the review intended to look at the geo-political description of the Emirates, Emergency Medical Technician-Basic (EMT-B), their scope of practice and POCT with End Tidal Carbon Dioxide ($ETCO_2$) and Capnography being the points of focus. In addition, the prehospital use of Capnography, its significance and the organizations that advocated its use, formed the main strata of enquiry to establish existing knowledge and also provided context to the study. With the advent of newer technology, coupled with 'skill shifting' initiatives, the EMT-B frontline workers were exposed to potential for enhanced clinical practices in their skill sets. Therefore, these parameters were areas of interest that informed the study initially, and was later expanded to explore POCT of $ETCO_2$ and the value and risk proposition of EMT-B scope enhancement.

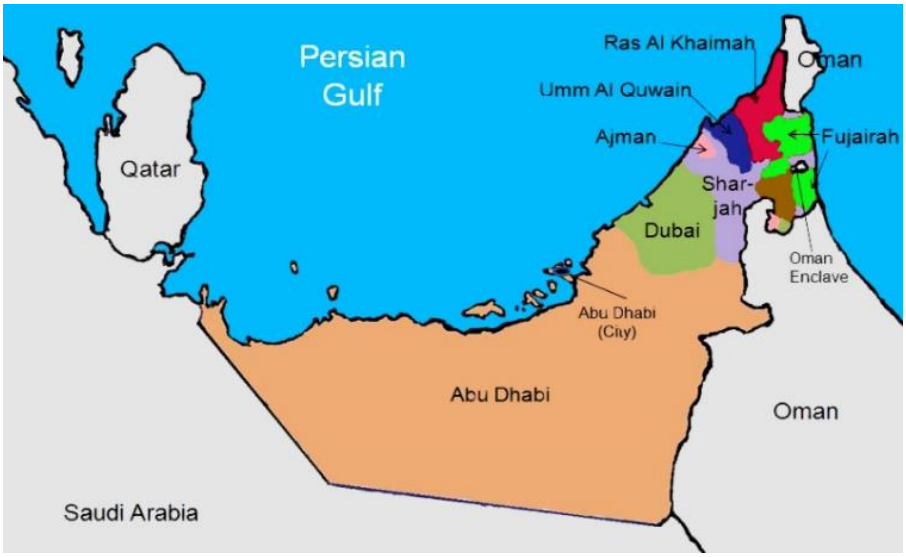
Search engines employed in the retrieval of research articles, publications, news and illustrations include the following: PubMed, Google Search, Medline and Research Gate, Science Direct, Elsevier.

Key Search Terms included: Capnometry, Capnography, $ETCO_2$ use, Prehospital capnography, EMS capnography, EMS Point of Care Tests.

2. 2. Geo-political description of study setting:

The United Arab Emirates (UAE), a 'desert-country', is a federation of seven emirates that was unified late in the year 1971. Abu Dhabi, Dubai, Sharjah, Ajman, Umm-Al-Quwain, Ras-Al-Khaimah and Fujairah Emirates make up the UAE. Abu Dhabi and Dubai are the main metropoles in the south and the other five smaller emirates are commonly referred to as the northern emirates. Discovery of oil had significant impact in the rapid development of the economy and industrial growth with impact on the demographics of the country. Health care spending in 2017 accounted for 8.6% of the GDP, valued at 4.2 Billion United Arab Emirates Dirhams (AED) and increased by 4.7% to 4.5 Billion (AED) in 2018 (Moonesar, Elsholkamy and Syani, 2018). The need for health care reform imperatives included affordability of health access to all income level earners, the recognition that there was room for improvement of quality and accessibility the health care. The latter was based more on access to limited physician specialists with affordability being one of the criterion (Moonesar, Elsholkamy and Syani, 2018).

Between 1975 and 2005 the UAE was considered to have the highest growth rate with population increasing seven-fold during this period (Population of the UAE, 2014). The UAE population for the year 2016 was estimated at 9,121,167 according to administrative records available with the Federal Competitiveness and Statistics Authority (FCSA) with further projections in 2018. The population administrative records also showed that 6,298,294 are male and 2,822,873 are female, making the gender split in the UAE 69% male and 31% female (Fanack, 2020).



Map of United Arab Emirates (Fig. 3)

The high population growth due to the immigration expatriate worker diluted the local Emirati population down to less than twenty percent (20%) in UAE. In the clinical setting, the physician ratio in 2008 was reported at 1.98 per 1000 population (Fares, *et al.*, 2014). There was dramatic improvements in the health sector and since then the figure in 2015 stood at 1 per 447 and nursing staff ratio was at 1:199 (Moonesar, Elsholkamy and Syani, 2018). Unfortunately, the Emergency care demographics was not captured in the report. However, National Ambulance being the primary provider of emergency care in the Northern Emirates Areas of UAE, the staff deployed permanently to these areas (N = 438) will serve as reference of EMS coverage in the area that stands at 1: 6849 (unconfirmed). As with the general trend of staffing in the UAE, more than 80% of the clinical staff are expatriate (Fares, *et al.*, 2014). The population among the different emirates was skewed by the industrial development of the bigger cities. Dubai, Abu Dhabi (Capital) and Sharjah Emirates accounted for 66% of the population while the remaining 33% was split among other emirates (Fares, *et al.*, 2014). The health care systems also developed according to the industrial growth and are proportionately skewed. With the growth spurt the paucity of emergency care research in the UAE during this period can be understood (Fares, *et al.*, 2014).

The 2018 projections were based on the last known official population figures released by the UAE government. Many factors and events affect the growth rate especially with the majority migrant populations. The UAE government has conducted four (4) censuses, with the last official census in 2005. At that stage Abu Dhabi was reflected as the most populated emirate being the capital of the UAE. Much has changed with the rapid development and growth in Dubai that has now taken the lead in being the most populated at approximately 3.32 million people with the recent dynamics of the Covid-19 pandemic unaccounted for. The population spread highlights the lower densities of the northern emirates given the lower populations spread (Global Media Insight, 2020).

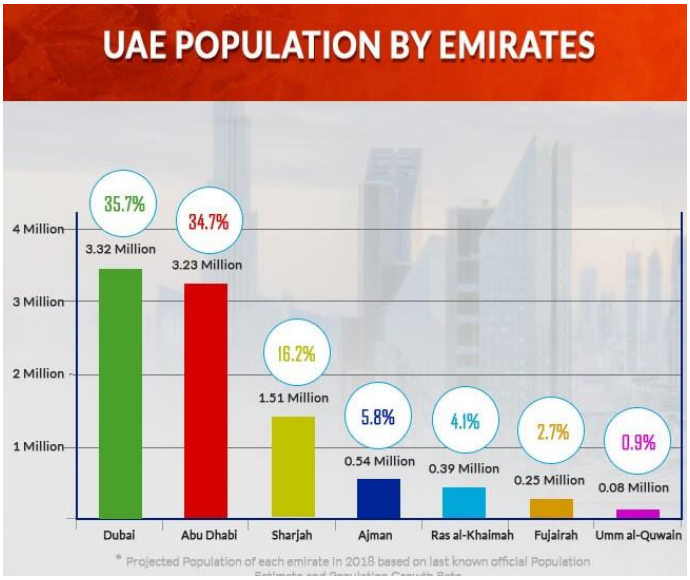


Fig. 4. UAE Population Projections (2018) by Emirates (UAE Population 2020 infographics accessed August 2020).

The demographics presented in Fig 4. highlight the less developed Northern Emirates that make up significant geographic dessert and mountainous areas of the UAE, with smaller populations and are characterized by longer distances for access to resources. Therefore, extended travel distances, developing health systems, lack of advanced medical resources characterizes these emirates and sets the tone for Emergency Medical Service (EMS) provision. National Ambulance being the sole EMS provider in these outlying desert regions with an EMT-B workforce, is part of the context for the proposed study. The emergency care workers in this setting need all the technological diagnostic support they can access, to care for their patients. Therefore, the diagnostic ability and support of diagnostic tools for decision making for this cadre of staff can have significant impact on EMS quality of care provision, given the austere setting.

2. 3. Emergency Medical Technician-Basic

The primary focus of the Emergency Medical Technician- Basic (EMT-B) around the world is to provide basic emergency medical care and transportation for critical and emergent patients who access the emergency medical system. This individual possesses the basic knowledge and skills necessary to provide patient care and transportation (Samuels, 1992). EMT-Bs performs clinical interventions with the basic equipment typically found on an ambulance. One of the eligibility requirements for licensure at this level requires successful completion of an accredited Emergency Medical Technician–Basic Life Support course. These programs typically range from four-to-eight weeks with intensive education, training and practice on Basic Life Support (BLS) resuscitation and other basic interventions. The EMT-B must recognize common emergencies and act to mitigate the physiological insult and sustain life (Samuels, 1992).

The education and training for EMTs was historically, not conducted in the UAE. The imported health expertise comes at a cost, and the acquired skill-set is expected to plug the gaps for local health requirements in public and private sectors. At National Ambulance, almost all the EMT-B staff is recruited from the Philippines. The prerequisite for employment at National Ambulance is that the applicants for the EMT-B Positions should have a recognized EMT qualification and a minimum of two years' practical experience as an EMT-B in an operational capacity. The EMT qualification and registration is regulated in the Philippines through the Emergency Medical Services Systems Act that was promulgated in 2009 (Philippines, no date). The NREMT education package is widely used for training in the Philippines. The vast majority of the EMT-Bs already has a Bachelor's Degree in Nursing, and then they embark on an EMT programme to enhance employment opportunities. Other staff employed at National Ambulance, with EMT registration have come through Fire and Emergency Services that embark only on the vocational training. The positive aspect of the EMT-Bs having a nursing degree background is that they have good foundational health sciences knowledge and therefore, introducing an extended clinical scope could be considered. A negative factor in the current setting may be those EMT-Bs that have not attained a nursing degree. However, the implication of an undergraduate has not been established to date and this study intended to track the differences between the two groups in terms of the uptake and application of POCT Capnography as a variable.

The business model of the National Ambulance includes offerings in EMS operations, consultancy, training, special projects and events, and aeromedical services. The primary function is the provision of frontline EMS, with the company boasting state-of-the-art ambulances and equipment. National Ambulance offers international standards of care by maintaining Joint Commission International (JCI) and International Standards Operations (ISO) ratings, which only one other EMS organization in the Middle East has equivalency.

National Ambulance hosts approximately 350 emergency requests per day in the northern emirates alone. On average, approximately, fifty (50) ambulances are distributed in the five Northern Emirates of UAE with about four-hundred and thirty eight (438) EMT-B staff deployed to these areas (on a shift system) to serve a population of about 2.7 million (Coyne, 2020). Majority of the EMS caseload is trauma related cases with Road Traffic Accidents (RTA's) accounting for a large percentage of trauma burden (Fares, *et al.*, 2014).

The frontline workers are the EMT-Bs that have been trained and qualified overseas and then employed in the UAE. The local health authorities (UAE) regulate licensure to practice at all clinical levels. In the decentralized system the emirates have independent health authority however they all fall under the Ministry of Health that also regulates EMS (Fares, *et al.*, 2014). As part of the EMT qualification verification and competency evaluation, all EMTs requiring to be registered in the UAE by the health authority, have to attend a computer cased cognitive and psychomotor assessments administered by the local health departments to be eligible for registration and local practice (DOH Abu Dhabi, 2020). The local Department of Health (DOH) accepted categories of EMT licensing in the UAE are Emergency Care Technician (EMT) Basic (B), Intermediate (I) and Advanced (A). Licensure is renewable every two years based on Continuous Professional Development (CPD) activity and currency of compliance (Rules, 2017).

In the UAE, the EMT-B scope is outlined in the National Ambulance Policy (CGF 169 – Policy for approval of Clinical Privileges) which allows EMTs to practice according to an approved scope by the Medical Director who, takes legal responsibility for clinical services supplied by the company (Ayman; Cummins, 2019). The EMT-Bs scope of practice is usually confined to basic, non-invasive interventions that may help to reduce morbidity and mortality with a limited and specified clinical practice parameters (DOH Abu Dhabi, 2020). EMT-B practice is limited to attending to patients and identifying any life-threatening medical or trauma conditions to stabilize and transport the patient to a definitive health center. Care is based on basic clinical findings and minimizing secondary injury, while providing comfort to the patient and family in transit to a medical facility. The EMT-Bs focus on, airway, breathing and circulation interventions primarily; but deal with a large spectrum of patients and encounter trauma, medical, obstetric, pediatric or geriatric patients. They have to assess, stabilize and transport these patients. The EMT-Bs have access to limited medications that are safe to use at a basic level, usually with minimal complication rates such as paracetamol or a nitrous oxide gas for pain relief as examples. The EMT-B scope of practice is attached for reference as 'Annexure C'.

In order to practice as an EMT–B, one has to attain a Basic Life Support EMT qualification from their country of origin, with proven two-year licensed practice experience, plus show competency in certain skills and procedures prior to the award. A successful program completion usually serves as acceptable record. In the (CGF 169) Policy for Approval of Clinical Privileges it is

noted that EMT-Bs are allowed to perform Point-of-Care Tests that include the use of diagnostic devices to assess blood glucose, oxygen saturation, temperature and end-tidal CO_2. Therefore, for all intents and purposes, the EMT-Bs at National Ambulance is presumed capable of $ETCO_2$ monitoring as part of their diagnostic scope guided by protocols. However, in a recently released health publication $ETCO_2$ is not listed within the scope of an EMT-B (DOH Abu Dhabi, 2020). Also, noteworthy, is that the EMT-Bs are awarded an extended scope of practice that allows for Supraglottic Airway placements, adrenaline administration (for resuscitation) and intravenous venous injection (IVI) for fluid administration. These extended skills are considerably beyond the normal scope of comparable EMT-Bs but was sanctioned (Ayman, 2019) by the local Health Authority due to the perceived need for care and the scarce resources experienced in the outlying areas of the UAE. Education, training and evaluation of all the extended skills have been conducted to ensure safe practice. The EMT-Bs procedures and actions are guided by Protocols CGP 134 Patient Care Protocols (Ayman; Cummins, 2019). The perceptions on implementation, use and support of point-of-care tests and diagnostic abilities of the EMT-Bs have not been evaluated before, nor has the trends in implementation been analyzed hitherto. Therefore, this study bears relevance to the $ETCO_2$ practice, as a point-of-care tool resource available to EMT-Bs in the UAE setting.

2. 4. Point-of-Care Testing

Point-of-Care Testing (POCT) have been used by clinicians for many years but only recently acquired the term 'POCT' (1994) in literature. Clinicians in all areas of health recognize and understand the implications of point-of-care tests (Plebani, 2009). POCT is usually performed by non-laboratory trained personnel such as nurses, paramedics, doctors, doctor assistants and a host of others with the advantages of quick turn-around times for results with minimal sample sizes (Joint Commission International, 2019). Factors such as, patient centered care, health decentralization, increase in the prevalence of infectious and lifestyle diseases, such as hypertension, diabetes and heart disease as well as advances in technology all have influenced the availability and use of POCT. However, it should be noted the variability of testing factors as well as the clinician competency can have impact in the quality and result of the POCT test (Joint Commission International, 2019). The Joint Commission International (JCI) that sets standards for health care make the point that to ensure that POCT is safely and correctly performed, users should have a clearly defined and structured approach to POCT testing. In the $ETCO_2$ study these factors were included and reported on. The JCI further suggest that following the initial training of a POCT, that there should be follow-up and competency checks, that should be performed regularly to ensure accuracy and reliability of results and safe patient care (Joint Commission International, 2019).

In a clinical review by Price (2017) on point-of-care testing, he concluded that with advancements in technology, a wider range of tests can be provided at the point-of-care. Also, the use of POCT is said to increase as medicine evolves and patients take more responsibility for their health and that rapid provision of results can facilitate better decision making (Willmott and Arrowsmith, 2013). Currently, non-invasive physiological vital sign measurements such as temperature pulse rate, pulse oximetry and blood pressure are now available to the public on smart wearable devices (Dias and Cunha, 2018).

Price (2017), in his review highlighted some important points in collaboration with the NHS Trust that is significant for the current study. They are that: a) POCT require trained operators to ensure quality results; b) Testing is effective only if action is taken on the result; c) From cost perspective POCT may be associated to a wider economic benefit, in that where the POCT seems expensive initially the decrease hospital stay or better patient outcomes may compensate for the costs (Willmott and Arrowsmith, 2013).

Therefore, the current study intended to explore the training (as one of the variables) associated with EMT-B lead capnography. This may help guide EMS with POCT implementation measures in future. The other area that was explored was the actions taken by the EMT-Bs after training, and this was monitored through usage of the capnography trends. Reporting on these trends was valuable in identifying areas of strengths and weaknesses in the implementation processes.

Notwithstanding the cost benefit of upskilling existing staff, EMT-Bs may be in a better position to use capnography for clinical scenarios of resuscitation, head injury, respiratory pathologies etc. However, the opportunity to apply POCT in these scenarios had not been established and therefore had to be analyzed in the study to determine the uptake of use at EMT-B level. The question of risk also arises and given the nature of the capnography being a non-invasive test, that could provide immediate objective feedback to guide patient care. The emergency care interest must align with patient safety (Naidoo, Zalgoanker and Christopher, 2014). Justification of POCT may be one issue but the actual interpretation and action trends could provide more information in terms of preparedness and perceptions of the practitioner, and also safety of the patient.

2.5. Significance of capnography as a POCT

Often capnography is referred to as the 6th vital sign in prehospital care (Johnson, Schweitzer and Ahrens, 2011). The American Heart Association advocates the use of capnography to confirm the proper endotracheal (ET) tube placement immediately after intubation of a patient as well for monitoring during transport (Link, *et al*., 2015). Capnography in the prehospital setting is a

valuable tool however, not all patients transported are intubated. This raises the question if capnography can be monitored in patients that are spontaneously breathing and not necessarily intubated? Wahlen, *et al.* (2003), conducted a study on 350 patients in the pre-hospital setting, measuring the end-tidal carbon dioxide in spontaneously breathing patients (Wahlen, Bey and Wolke, 2003). Although it was a physician-lead service in a Mobile Intensive Care unit (MICU), the medical pathologies that was considered for capnography monitoring was of interest to this study. Patients that were included in his study, had intoxication, neurological, respiratory, cardiovascular and other medical disorders. The results of the study highlighted that there was a 5% error rate in spontaneous breathing patients that was attributed to mouth breathing with a nasal cannula (monitoring instrument) and other factors such as water vapor and occlusion of the nasal cannula by secretions and mucous. However, the majority monitored provided useful information. Elevated $ETCO_2$ levels (> 8kpa) was observed in some patients with Asthma, subarachnoid hemorrhage, seizures, drug intoxication (4-5.7 KPa is considered normal) while low $ETCO_2$ levels was observed in patients that were hyperventilated (Wahlen, Bey and Wolke, 2003). Therefore, where there is a reliance on vital signs to make clinical judgement, continuous capnography in critical situations can provide useful information on the patient's ventilatory status as well as (under stable conditions) an indication of circulation and metabolism (Siegrist and Siegrist, 2016). Other than monitoring the placement of the ET Tube, the use of capnography for some clinical conditions could provide immediate and useful information even with spontaneously breathing patients and this is significant for the current study as majority of the patients being treated at Basic Life Support level would be conscious and spontaneous breathing patients (Eastwood, *et al.*, 2018). This is supported by recent evidence emerging from the historical data review of the EMS cases in northern emirates, where 32 558 of the patients were recorded being fully alert with a Glasgow Coma Scale (GCS)15/15, featured in the results.

2.6. Prehospital uses of capnography:

Capnography has applications in patient monitoring for the intubated patients as well as non-intubated patients. In the application of intubated[6] patients, capnography is said to provide information on: a) Confirmation of ET tube placement; b) Continuous monitoring of the ET Tube and indication of tube dislodgement; c) Monitoring of effective Cardio-Pulmonary Resuscitation (CPR) and early detection of Return of Spontaneous Circulation (ROSC) (Siegrist and Siegrist, 2016).

The non-intubated patients in the emergency care pre-hospital setting are of particular interest for the EMT-B community as their scope excludes intubation[8] and CO_2 monitoring of this group of patients draws attention to its' ($ETCO_2$) applications as an emerging standard. Capnography can provide valuable information on patients with: a) Ventilatory compromise (COPD, hyper and hypoventilation, apnea or inadequate breathing, monitoring during sedation, monitoring of $ETC0_2$ during head injury); b) Metabolic compromise (diabetic ketoacidosis, hypermetabolic states); c) Circulatory compromise with shock, (Wahlen, Bey and Wolke, 2003). The majority of pre-hospital technicians at Basic Life Support level (EMT-Bs) that encounter such patients on a regular basis ought to be capacitated to deal with their clinical burden. $ETCO_2$ monitoring can be considered a low-cost quick and safe method of enhancing patient safety with the potential to increase the clinicians diagnostic capability (Manifold, *et al.*, 2013).

Basis (2009) highlighted that first-responders and EMT-Bs operated advanced equipment such as bag-mask-resuscitators, facial masks, oxygen equipment and monitors and they would be able to use portable $ETCO_2$ mainstream monitors with little training but were not currently (2009) certified to do so (Basis, 2009), more than a decade later not much has changed. Bag Mask Ventilation use is quite intense and requires concentration and skill to be used effectively. Ventilation with a Bag Mask is technical and considered a two-person operation (Bucher and Cooper, 2018). Therefore, a single EMT-B assisting patient ventilation can be quite challenging and capnography may serve as an objective guide to the effectiveness of the ventilation.

Donald (2006) published an article in the Emergency Medicine Journal Online highlighting the advent of new technology and the portability of capnography and its use in emergency services. This was a critical expression of the capnography role in the pre-hospital emergency medicine arena. Objective indication of patient's $ETCO_2$ parameters could now be measured at the patient on the roadside (or some other austere environment) and the implications were significant. Although at this stage, the primary function of capnography was still limited to confirmation of placement of the ET Tube. The publication drew attention to the expanded role of capnography in the clinical management of secondary brain injury, control of ventilation, safety during transport and also its use as a prognostic indicator in the pre-hospital environment (Donald, 2006). The publication would also develop many more roles going forward in supporting learning, practice and advances for the EMTs in EMS. Alas, more than a decade later the EMS are still grappling with implementation and use of these POCT, even at advanced levels of care (Wylie, Welzel and Hodkinson, 2019).

[8] Intubation*:* the insertion of a tube into a patient's body, especially that of artificial ventilation tube into the trachea.

In recent years Capnography has been established as a 'Gold Standard' as a quality measure of chest compression quality as well as an indicator of Return of Spontaneous Circulation (ROSC) (Pantazopoulos, *et al.*, 2015). Capnography as a POCT in resuscitation, is a recognized marker for decision and intervention strategies in resuscitation attempts (Heradstveit and Heltne, 2014). Confirmation of the ET placement, the quality of chest compressions, the possibility of ROSC and the decision to terminate resuscitation attempts can be informed by POCT $ETCO_2$ tracking. All of these are significant in a cardio-pulmonary resuscitation and capnography as a POCT may trigger changes in the way they manage the patient further (Heradstveit and Heltne, 2014). Capnography use for resuscitation has been recognized as an objective tool for monitoring quality of chest compression and has been related to positive outcomes for patients (Link, *et al.*, 2015). Evidence shows that capnography as a POCT has relevance for the prehospital emergency care (Price, 2017); but the evidence of use and perception by clinicians is lacking generally, but even more so at EMT-B levels of care and this study delves into these areas of enquiry.

Ventilation and oxygenation are interrelated however, there usually is an assumption that the two go together and as long as one is fine, so should the other. Using an example of Asthma where there may be a patient with mild to moderate Asthma, the patient may be displaying signs of adequate blood oxygen saturation (SaO_2) however, ventilation may be quite labored and compromised. So, whilst the oxygenation may be maintained, the ventilation related to elimination of carbon-di-oxide (CO_2) may lead to a build-up over time thus eventually affecting the oxygen saturation as well. Oxygen loading onto hemoglobin is related to the CO_2 offloading (Wemplar David A., 2011). Capnography in Asthma patients has been shown to be of immense value. The typical ''Shark Fin" waveform with varying degrees of acuteness of the waveform angle (on Capnography) correlates to the severity of the bronchospasm and directly relates to airflow affecting CO_2 elimination as well as O_2 inflow and uptake (Howe, *et al.*, 2011). Therefore, capnography as a POCT tool can help determine the severity of the bronchospasm and also note changes in relation to therapy provided with continuous monitoring. Researchers have shown capnography as a more reliable and specific tool to monitor the Asthma patient over the conventional Peak Flow Meter that was conventionally used (Howe, *et al.*, 2011). EMT-Bs in the current study also treat Asthma patients and aside from the stethoscope, have no other equipment to help assess airflow. With a tool like capnography, they can not only measure severity but also response to treatment regimes.

Capnography can also be used to indicate early warning signs of shock (Aminiahidashti, *et al.*, 2018). A patient with relatively normal ventilation that shows sudden drop in CO_2 levels point towards a perfusion problem as with a patient in shock. The suggestion is that capnography should be used with trauma, cardiac or any other patient prone to shock (Wemplar David A., 2011). A patient with low cardiac output will not deliver as much O_2 back to the pulmonary circuit, thus resulting in decreased $ETCO_2$ level and may serve as warning to the EMT-B. However, with

shock or perfusion related pathologies, there are other mechanisms of warning that are available in the EMS setting. ECG monitoring is standard across all EMS vehicles deployed to the Northern Emirates and available to the study cohort. Therefore, monitoring of pulse rates, blood pressure, patient color and patient perfusion is common practice and may serve to highlight perfusion issues (Ayman; Cummins, 2019). Further, the National Ambulance have programmed the electronic patient care record platform to automatically calculate the patient 'Shock Index' as the patient vital signs are entered into the device it alerts the EMT-B practitioners. Therefore, the use of a POCT tool to highlight a perfusion problem or shock may be used as a secondary or tertiary tool if at all. Therefore, for the purpose of the current study, the emphasis on capnography use in relation to shock is minimal.

2.7. Established Pre-Hospital entities that support the use of Capnography:

In 2015 the International Liaison Committee on Resuscitation (ILCOR) released an evidence paper supporting newer resuscitation guidelines based on extensive research with consensus from member organizations (Link, *et al*. 2015). The initial phase of the publication review, highlighted the use of physiological monitoring parameters in resuscitation as providing valuable information on the patient response to therapy as well as the patient condition, without interruption. Capnography when available was shown to optimize CPR quality and also served as an indicator of ROSC, (Link, *et al*. 2015). In the UAE context, the frontline staff (by majority) do almost all the Cardio-pulmonary Resuscitations (CPR) and are the EMT-B group that also have access to $ETCO_2$ monitoring. The use of capnography POCT to optimize resuscitation attempts can be a valuable tool in (CPR) resuscitation attempts (Pantazopoulos, *et al.*, 2015).

The EMT-Bs at National Ambulance are also permitted to place Supra-glottic Airways (SGA) for patients that are being resuscitated or unconscious patients that cannot protect their airways, this presents another opportunity for the use for $ETCO_2$ monitoring. Unfortunately, in the American Heart Association (AHA) Resuscitation Guideline 2015 review, there were no actual studies conducted that tested the efficacy of $ETCO_2$ monitoring for confirmation of placement of these (SGA) adjuncts (Link, *et al*. 2015). However, in the update revision of the ILCOR Guidelines (2015), it was highlighted that continuous waveform capnography 'could' be used for sampling of an SGA or an airway with a leak. Therefore, in this current study, SGA positioning, was also analyzed.

The National Association for Emergency Care Technicians (NAEMT) formed in 1975, is also another group involved in emergency care resuscitation with an international membership of more that seventy-two thousand (72 000) Emergency Medical Technicians at various levels of qualifications. NAEMT in collaboration with the American College of Surgeons (ACS) have

published the Pre-Hospital Trauma Life Support (PHTLS) textbook that is used extensively in the EMS setting for information and guidance on the care of trauma patients. The text is based on emerging clinical research and can be used as an American based reference for emergency care practitioners in the pre-hospital sector.

NAEMT recognizes the use of $ETCO_2$ monitoring in the pre-hospital environment. Emphasis on regulating the patient respirations, to help moderate rising intra-cranial pressures in a head injured patient is made. In Chapter 9: Head Injuries of their text, the use of $ETCO_2$ to control the rate of ventilation is advocated, this should be done in correlation to the exhaled carbon-dioxide parameters as a point-of-care/ monitoring tool for reducing the insult of a secondary injury to the brain (PHTLS 9th Edition; Basis, 2009). Again, frontline clinicians that treat majority of the head injured patients are EMT-Bs and access to capnography may have direct bearing on head injury patient care.

2. 8. Resources required for capnography:

There are several different methods of measuring carbon dioxide (CO_2) levels in expired gas, however, in the out-of-hospital setting there is limitation to either a Colorimetric Detector or Electronic Monitors with built in Infra-Red Spectroscopy (Pedras, 2019)[,]. The colorimetric detector comprises of a plastic film with a deprotonated form of a dye and carbon di-oxide both of which have a 1:1 equilibrium reaction (Donald and Paterson, 2006). In the presence of exhaled carbon di-oxide the film changes color as objective detection of the gas. Although the colorimetric detection serves as confirmation that expired air (CO_2) is present in the gas with a reasonable reaction time, and a good shelf life, the reliability of this device is subjective. The colorimetric device becomes less effective over time and therefore unreliable for the longer term use (Pedras, 2019).

At National Ambulance, all ambulances are equipped with LifePack15 Monitors / Defibrillator / Pacing machines that also include a capnography as one of the features. The LifePak15 Monitor unit is configured to analyze a side-stream sample of gas from the patient's respiratory cycle. Some advantages of this type of sampling method is that it is easy to connect and to use irrespective of patient position while sterilization concerns are minimal (Kerslake and Kelly, 2017).

The other unique advantage of the side-stream sample monitoring system is that it allows for sampling of non-intubated, spontaneous breathing patients with the use of adapted nasal tubes (Kerslake and Kelly, 2017). This has particularly relevance in the current study, where majority of the patients being treated at EMT-B level may be spontaneous breathing patients and the

broader uses of capnography can be explored. Yet, another advantage is that sampling can be done without interruption of oxygen supply in the non-intubated patients (Kerslake and Kelly, 2017). As expected, there are also some disadvantages of capnography use, like the inaccurate recording with spontaneous breathing patients monitoring. This is highlighted by (Howe, *et al.*, 2011) and is disused further in the discussion section of the study. The survey responses were designed to get more information from the experiences of the EMT-Bs on the $ETCO_2$ monitoring of spontaneous breathing patients. The basic airway program that the EMT-Bs are exposed to, gives an introduction to capnography only. The determination of false positives and negatives is yet to be tested but is not an objective of the current study.

2. 9. Policies, procedures or guidelines for capnography use:

To date this area lacks direct evidence. Thus far, research papers for pre-hospital protocols for capnography are limited. The AHA, NAEMT and tertiary education institutions provide parameters and guidelines (as already stated) for use however, operational policies at institutional levels are lacking. The National Ambulance have Patient Care Protocols that have been adopted as a Policy (CGP 134, v.2, 2019) and remains as a guide to practice. The CGP 134 Clinical Practice Protocols refers to $ETCO_2$ monitoring at an EMT-B level of care in a number of scenarios. Therefore, there is advocacy for the use of $ETCO_2$ point-of-care testing, as a guide for the management of patients. However, formal adoption into the EMT-B scope of practice remains only a consideration at this stage. The usage trends, understanding and perceptions of staff for the use of $ETCO_2$ are interrogated in this context.

2.10. Task Shifting

Task shifting is a term given to a process of delegation whereby tasks are moved, where appropriate to less specialized health workers (Kirtley, 1996). Often task shifting can often be seen as a solution to the health worker crisis, coverage and access to health, a cost saving and an improvement in efficiency. Conversely, some of the limitations of task shifting can be conflict between professionals, doubts about care administered and lack of satisfaction, short term increase in investment related to training, harm or risk to patient safety, the need for continuous oversight, may help in the short-term but, not considered sustainable. In an article by the WHO (1996) titled: Task shifting to Tackle Health Worker Shortages, it was acknowledged that the world was experiencing a chronic shortage of well-trained health workers with numerous countries experiencing crippling effect, and there was a dire need to fill the gap (Kirtley, 1996). Task shifting is a radical move from conventional methods of health care delivery and with the given risks both the patient and the health worker need to be protected. Through behavior

changes and management support quality of health care could be improved with monitoring and evaluation of the changes (Williams, 2000). Education and training of the health worker plays an important role in the transition of new tasking, and competency and administrative support and enabling environment (Williams, 2000). At National Ambulance the enhancement of the EMT-B clinical scope may be viewed similarly with $ETCO_2$ as POCT eligibility for the junior technicians. Therefore, training and education, management support and clinical exposure make up the tenets of the study enquiry. To date, quality parameters in task-shifting for the EMT-Bs have not been established and represents a gap in the procedural knowledge.

2.11. POCT and advances in technology.

In the advent of the 4th Industrial revolution digital age, technology is advancing in leaps and bounds and the impact on medical care is imminent (Klaus Schwab, 2016). In recent developments in the medical fraternity the pre-hospital EMS seems to already lagging way behind. Capnography use highlighting advantages were advocated more than a decade ago, yet the uptake of $ETCO_2$ as a POCT has been slow (Donald and Paterson, 2006). In the recent past the adoption of blood oxygen saturation pulse oximetry was well received. It has proven to have made an impact on EMT decision making with regard to the involvement of Advanced Life Support (ALS) and appropriate levels of care required for the patient (Van Dyk, *et al.*, 2004). However, now digital watches have monitoring capabilities that track heart rates, respiration, energy consumption etc. Further advances in monitoring ECG Rhythms, temperature, oxygen saturation, perspiration loss as point-of-care monitoring is already available to consumers with mobile phone technology. In the occurrence of an adverse event the mobile phone has the ability to automatically transmit the occurrence to the individual's (pre-programmed) physician. The new trend in Biomedical Research and Innovation is a focus on Wearable Health Devices (WHD) that empowers individuals do self-tracking and take accountability for their own health. Innovations in wearable devices for electrocardiogram, heart rate, blood pressure, respiration rate, blood oxygen saturation, blood glucose, skin perspiration, capnography, body temperature, motion evaluation, cardiac implantable devices and ambient parameters as well as integration of sensors into materials or clothing that is wearable (Dias and Cunha, 2018) have already been devised. Although, these innovations may have limitations when compared to certified medical monitoring equipment, the conventional medical fraternity seems to be lagging in development and training. Maybe, it is time for EMS to review the EMT clinical scope to try and bridge the growing gap. Otherwise, we may be faced with the patient having more access to clinical information than the care-giver can cope with. The current study intends to make a step in the direction of progress with the analysis of newer interventions that can benefit the patient and

also increase efficiency from identifying any gaps (if any) and supporting EMT-B POCT enhancements.

2.12. Summary

Given the above evidence of the review, it is clear that $ETCO_2$ and capnography use is a significant POCT tool, and has a place in the emergency medical care setting. The employment of such a tool is not only given significance but also advocated for prehospital use in many scenarios and by many EMS authorities. There seems to be a paucity of evidence in adoption capnography as a POCT tool in the prehospital setting. Also, given the limited scope of practice of the EMT-Bs in Emergency Medical Services (EMS) the inclusion of capnography in the EMT-B clinical scope is even less documented. In the UAE the EMT-Bs have access to capnography but are they using the tool? Have they been exposed to knowledge on $ETCO_2$ enough to understand the value and implications of capnography as a POCT tool? These are areas of enquiry that are covered in the study. Therefore, the current study has relevance and value in contributing to EMT-B practices in the EMS settings. Also, the outcome of the study may serve to inform the implementation of best practices in patient care, given newer innovations in technology availability. The study may be used to advise scope change considerations for the future and also create awareness of $ETCO_2$ as a POCT tool that can enhance clinical practice in the future for EMS systems that may wish to embark on such endeavors.

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Chapter 3 – Methodology

3.1. Introduction

The historical data use of $ETCO_2$ trend review and EMT-B perceptions are analysed independently initially, then correlated and reanalysed. This section covers various processes of the study methodology but first draws attention to the objectives of the study for relevance. Sub-sections of processes contained include the Research Design, Data Source, Instrumentation, Data Collection Procedure, Internal & External Validity, Data Processing and Analysis, Ethical Principles, Bias and a Summary of the Methodology process.

3.2. Aim:

To document how the inclusion of point-of-care testing (POCT) through capnography, enhances (or complicates) the diagnostic capability of EMT-Bs in the UAE.

3.3. Objectives of the Study

Table 1: Objectives, Questions, Purpose and Methods Summary

Objectives	Emergent Questions	Purpose	Method
3.3.1. To provide an epidemiological description of $ETCO_2$ application by EMT-Bs'.	What are the records reflecting on the adoption of $ETCO_2$ use by EMT-Bs in the UAE?	To evidence the uptake of capnography as an POCT tool in the EMT-B enhancement process.	Archival research: Trend analysis from retrospective patient medical records
3.3.2. To document the EMT-Bs self-perception of the inclusion of $ETCO_2$ into their clinical scope.	What has been the EMT-Bs exposure and perceptions of $ETCO_2$/Capnography in support of their diagnostic abilities?	To determine if POCT capnography is helpful or a hindrance at EMT-B level, and can they take on capnography as a POCT tool going forward.	Prospective survey: Self - directed questionnaire with EMT-Bs in the northern emirates of UAE.
3.3.3. To provide context to task shifting in settings of greater need than resources availability, while exploring opportunities and risks	What are the opportunities presented and risks?	To determine the support that EMT-Bs may require for safe capnography use to be sustained.	Literature Review on behaviour change in adopting new skills recommendations

3.4. Appropriateness of the Research Design

3.4.1. Research Approach and Design

A post-positivist paradigm using a deductive approach was the design adopted for this study. Data of an empirical (quantitative) nature was collected and analysed retrospectively (Phase 2). In this part of the study, electronic data captured by Emergency Care Organization database was mined to extract details required to produce an epidemiological description of $ETCO_2$ practice. Subsequently, a practitioner survey (Phase 3) was used to prospectively extrapolate perceptions and diagnostic values (Table 1).

The evidence retrieved from processes above, then needed to be put into perspective. Taking into considerations factors such as the local, cultural, ethical and political influences in the Middle East (that are different to the western world) needed reporting to provide context, as well as highlight the confounding factors that may have influenced the results. The post-positivist paradigm allowed flexibility for this type of narrative to supplement the empirical evidence observed in this study.

3.4.2 Methodology

In the conceptual phase of the study, extensive literature reviews highlighted research initiatives on POCT $ETCO_2$ and capnography that have already been conducted, as well as the gaps of information especially dealing with the EMS and out-of-hospital setting. Once the problem was identified, emergent questions arose and helped define the objectives and the methods of inquiry. The two main objectives were identified were:

a) To provide an epidemiological description of $ETCO_2$ application by EMT-Bs and,
b) To document the EMT-Bs self-perception of the inclusion of $ETCO_2$ into their clinical scope.

In order to meet these objectives different approaches were applied:
Phase 2 comprised of a digital review of historical information retrieved from Patient Care Records (PCRs) from the National Ambulance database. This entailed an electronic download of specific data required for the study from the National Ambulance server database that was analyzed with specific areas of enquiry in line with the requirements, to meet the objectives of the study. Approximately 80 708 electronic Patient Care Records (PCRs) captured over a 12-month retrospective period was mined for data relevant to the study, with a record of 39 937 cases that may have had potential for capnography use. Case pathologies involving head injuries, respiratory compromise, shock and cardio-pulmonary resuscitation (CPR) cases mainly were reviewed, and compared with $ETCO_2$ being monitored oppose to not being used as Point-Of-Care Tests (POCT). Analysis of usage trends, bias, outcomes (e.g., in resuscitations) was analyzed and

reported on. A narrative associated to the empirical data for geopolitical, cultural and confounding factors contributed to the discussion through a post-positive perspective. The narrative provided clarity on the variables being analyzed and outcomes of the correlations in this historical review phase of the study. This was used to answer the objective of 'Providing an epidemiological description of $ETCO_2$ application by EMT-Bs.' The data collected in the historical review was segregated according to geographical locations as captured on the PCR, and allowed for correlation among the various emirates in the north of UAE. The gaps or points of interest that emerged from this part (Phase 2) of the study informed the survey (3^{rd} Phase of the study) that delved into the second objective: To document the Basic EMTs self-perception of the inclusion of $ETCO_2$ into their clinical scope.

Phase 3: A Survey Questionnaire, was used to inform the study objective. The survey was constructed based on a literature review of previous similar studies (Wylie, Welzel and Hodkinson, 2019), as well as taking into account the current practice guidelines advocated by international emergency care organizations. Although other survey tools existed, the modifications required to meet the objectives of the current study warranted verification of the tool for effectiveness and compliance with research standards. Therefore, the survey tool was pilot tested for accuracy, reliability, validity and met the objectives of the study, then was subsequently tweaked (based on pilot feedback and advice) before the final roll-out to the study cohort. As mentioned previously, points of interest emerging from Phase 2 of the study was also incorporated into the survey for greater gap coverage. The survey was intended to help answer the objective of 'documenting the EMT-B's self-perception of the inclusion of $ETCO_2$ in their clinical scope.'

Data variables that were captured by the survey tool included categories of consent, demographic details, qualification and experience of the participants, training and exposure related to capnography, POCT tool availability in the work environment, in addition to the Knowledge, Skills and Attitudes of the EMT-Bs. Once these variables were captured and analyzed, they were cross correlated to Phase 2 of the study to provide a comprehensive analysis and lead to the conclusions and some recommendations. A synopsis of the process is detailed in Figure 5 below.

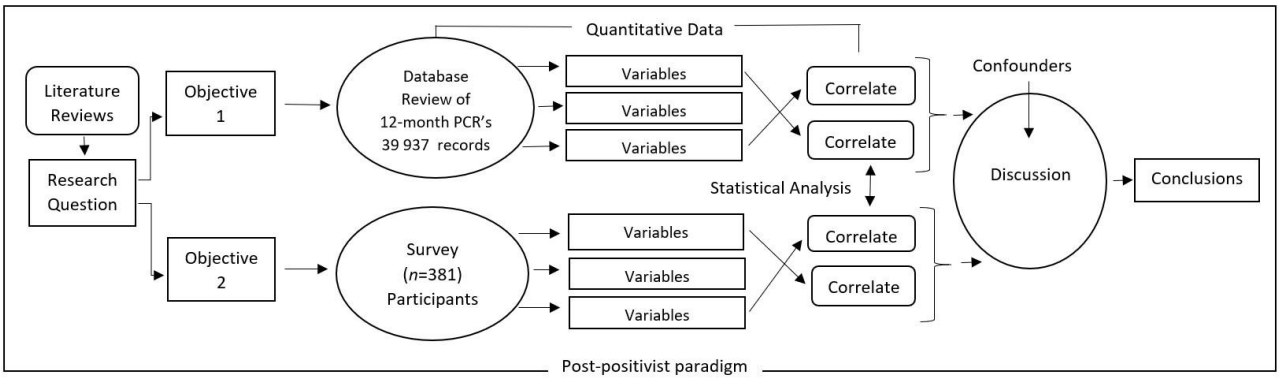

Figure 5. Research Design and Data Processing

3.5. Data Source

3.5.1 Phase 2 : Historical Data, Patient Care Records, Acquisition Process and handover of data are alluded to in this section. The source of the data is described together with the process that was involved in the access to the sensitive information and the handover of data is described.

So, where did the data originate? As already established, National Ambulance is the primary service provider of Emergency Medical Services (EMS) mandated by local government in the Northern Emirates. Together, with patient care meted out by the study population (EMT-Bs), extensive patient care data is collected on Patient Care Records (PCRs) in an electronic format. The clinical staff at National Ambulance are equipped with Mobile Data Terminal (MDT) tablets, that feed into a mainframe server established at National Ambulance Headquarters (HQ - Abu Dhabi). The MDT platforms have a Patient Care Record (PCR) template that gets populated with every patient case information. Details of the patient case and interaction is recorded for official and legal purposes. The PCR information spans across twenty-two (22) frames, with extensive information on the incident details, patient details, medical history, regular medications, injury details, history, patient examination, observations, patient ECGs, medications administered, management Interventions, handover Information as well as windows to capture case related images (Patient ID, Insurance Cards, Vehicle License Plates etc.) In addition to the basic PCR template, there are additional frames that are used to capture information on Cardiac Arrest Resuscitation cases. The resuscitation information is oriented to the Pan African Resuscitation Outcomes Study (PAROS) requirements and variables in terms of Cardio-Pulmonary Resuscitation (CPR) times, interventions, equipment used, transport, outcomes are recorded. Therefore, with an abundance of information available in the electronic format, the study data opportunity existed.

Given the sensitive nature of information involving patient care records, there was a process for the acquisition of data to be adhered to, and only when National Ambulance management granted access to the database for the purpose of the study, then information became accessible to the researcher. Initially, a letter of request for the $ETCO_2$ study was submitted to the National Ambulance CEO for permission to undertake such a study within the National Ambulance Company. (Annexure B – CEO Permission Request) attached, and a further application was made to the National Ambulance Research Committee. A proposal of the intended research study had to also be submitted, so that the Research Committee could have more detail on the application request. Access was granted to the dataset requirements as detailed in a comprehensive table that was designed by the researcher (Annexure D – Data Requirement Tables) is attached as reference.

The dataset was then extrapolated from the National Ambulance Database by the in-house IT Engineer into an Excel Document. Based on strict security, safekeeping and trust after signing an acknowledgement on conditions of data use, the National Ambulance allowed the release of the required dataset variables to the researcher to be used only as prescribed in the study proposal.

3.5.2 Phase 3 : Self-Perception Survey, EMT-B Practitioner Feedback and Trend Analysis.

This portion of data was sourced through a prospective survey and represented the EMT-B practitioner feedback, this is discussed in the instrumentation content.

3.6. Instrumentation

3.6.1. Phase 2: Patient Care Record Database Review (Data Collection Instrument)

Phase 2 instrumentation comprised of a digital review of Patient Care Records (PCR) from the National Ambulance database. An electronic download of specific data in a MS Excel® (program) format from the EMS server was compiled, formatted and analysed to review details required for meeting the objectives of the study. A total of 39 937 electronic PCRs where capnography was used or with potential $ETCO_2$ value, was captured over a 12-month retrospective period from 01st March 2019 to 29 February 2020. Cases such as Head Injuries, Respiratory Pathologies and Resuscitation cases (among other) was reviewed and compared with $ETCO_2$ being monitored opposed to not being used. Analysis of usage trends, bias, outcomes was reported on. A narrative was associated to the empirical data for geopolitical, cultural and general context. 'Annexure D' of the attached documents, provides clarity on the variables being analysed and the anticipated correlations for reporting. The historical data retrieved, was used to answer the objective of

providing an epidemiological description of $ETCO_2$ application by EMTBs. The data collected was also stratified according to geographical locations captured on the e-PCR (electronic patient care records). This allowed for cross comparison among the five emirates in the north of UAE. Gaps and points of interest emerging from Phase 2 of the study was factored into the survey (3rd Phase) to delve further into these areas for more information.

3.6.1.1. The Data Security and Handling

Data from the National Ambulance database was mined by the National Ambulance IT Department. The required data was specific to certain categories of patients that the potential for use of capnography was associated with (Basis, 2009). Only the requested data was released to the Principal Investigator (PI) after a National Ambulance Research Committee Member reviewed the detail for ethical, safety and security compliances. The data was then released in a digital format through a security coded shared folder managed by the Research Department Manager of National Ambulance. Bound by the National Ambulance Research Committees conditions of acceptance, the data use was strictly limited to the study purpose only. On completion of the study the shared folder with the contained data would be withdrawn completely.

The survey data also hosted on a National Ambulance subscribed platform (Survey Monkey) was secured with limited access to NA Management. On completion of the survey the final results were exported onto an Excel programme format, and shared with the principal investigator (PI) only. Again, subject to the same conditions as with the historical data, access to the survey data was withdrawn on completion of the study.

3.6.1.2. Data Filtration from the database included the following the following criteria:

- Period of data capture 01 March 2019 to 29 February 2020
- Total Case Load for the Capture Period was established at 80 708 (Database Review)
- In order to measure current trends in $ETCO_2$ use, the $ETCO_2$ was the primary filter for the data capture Time Period & Total Case Load, including pathologies for potential use of $ETCO_2$ amounted to thirty-nine thousand, nine-hundred and thirty-seven (39 937) cases.
- For the establishment of Potential Use of $ETCO_2$, case pathology categories need to be reviewed. This would include the following pathology categories (according to National Ambulance Pathology Coding system: Attached as Annexure H)
    i. Allergic Reactions

ii. Infectious Diseases - (this would include Covid-19 Cases)
iii. Breathing Difficulty
iv. Cardiac Arrest
v. Chocking
vi. Diabetes
vii. Environmental & Toxic Exposure
viii. Head & Neck
ix. Mental, Emotional & Psychiatric
x. OD, Poisoning
xi. Seizures
xii. Sick (unknown)/ Other
xiii. Stroke (CVA)
xiv. Unconscious
xv. Paediatrics
xvi. Assault/ Trauma
xvii. Burns
xviii. Drowning / Water Injury
xix. Falls / Accidents / Pain
xx. MVA

- The Case Load of the Potential Case Pathologies was, as anticipated, a significant portion of the database (N = 39 937).
- Analysis of potential for use of $ETCO_2$ was also established by assessing other criterion such as:
  i. Vital Signs (especially Respiratory Rates)
  ii. The use of BVM
  iii. When CPR is Initiated
  iv. SpO_2 levels
  v. $ETCO_2$ levels
  vi. Shock Index (SI) / Early Warning Score (EWS)

3.6.2. Phase 3: Survey Tool (Questionnaire)

A Survey Questionnaire tool was used for the third phase of the study, after the historical data trends had been reviewed. The purpose of the study was to try and understand the ambulance crew perceptions of capnography inclusion into their daily practice at an EMT-B level. The survey was constructed based on literature review of previous and similar studies (Wylie, Welzel and Hodkinson, 2019) as well as taking into account the current practice guidelines advocated by

global emergency care organizations. As mentioned previously, points of interest emerging from phase 2 of the study informed content of the survey to deal with some of the identified gaps of information. The content of the survey comprised of data variables that included the categories of consent, demographic details, education and exposure related to capnography POCT. The survey attempted to draw information on the knowledge, skills and attitudes of the EMT-Bs with their exposure the capnography in the EMS Setting of the UAE. 'Annexure E – EMT-B Survey Tool on $ETCO_2$' is attached as reference. The required variables were captured, compiled, analysed and then correlated with details retrieved from the historical trend review (Phase 2) of the study to provide a comprehensive analysis of 'Capnography and related diagnostic capability among Emergency Medical Technicians – Basic in the northern UAE'. The analysis and results are reported on in Chapter 4.

After analysis the Strengths, Weaknesses or Gaps of POCT implementation could be identified and conclusions and informed recommendations for Capnography use at EMT-B level.

3.6.3. Pilot study

The format and questions posed was tailored to meet the specific objectives of the study. Unlike the South African context of EMS operations, the EMS system in the UAE (northern emirates) with different management systems, operational equipment, policy and procedure, clinical staff, education and exposure etc. had to be considered in the tool design. The survey tool was pilot tested to ensure it could capture the required detail for the study and to ensure the set objectives could be met. Other factors like the accuracy, reliability, validity was also assessed in the pilot phase and the tool was adjusted as required (This is elaborated in the results and discussion).

The pilot testing was conducted on a sample EMT-Bs (n = 8) that was also part of the study population cohort. The pilot test was used to verify the tool effectiveness and be used as a guide to amend the tool as required prior to the administration to the larger cohort. The survey tools also tested against common pitfalls in survey design to help produce a quality tool (Artino, Gehlbach and Durning, 2011).

3.6.3.1 Feedback from the Pilot Study

A Survey Monkey link, was sent through e-mail to the Pilot Survey respondents for feedback and comment on issues of language, interpretation, access, information contained, graphs or any other feedback that would make the survey more user-friendly.

The main complaint was that the link, used to access the survey, accessed an Arabic version of the survey document. All the respondents are English speaking, so access to an English document was essential. Investigation lead to the reason being the default setting of preferred language based on geographical location (UAE) when accessed through Google®. Other feedback included, details of the demographic section of the survey, where various gender options were incorporated in an attempt to be politically and gender sensitively correct. The gender options were considered too many and caused distraction, therefore needed to be simplified. Another issue was raised in the education background field of responses. The question on training was considered vague, clarity was required whether informal training or a CME could be counted as formal training received. This had to be clarified to be more encompassing of previous training exposure. Some respondents also pointed out that the graph depicting CPR in the diagnostics section, was unclear and staff were not accustomed to seeing this view (graph). Also an insignificant dip in the graph was creating a distraction. The respondents were concentrating on the 'Dip' oppose to the overall trend. This had to be corrected to images that were more familiar to EMT-B staff in their current setting and resulted in modifications to the survey tool presented. One member of the 'pilot study' felt that due to the voluntary nature of the survey, that feedback may be low as staff were "Surveyed Out'' with numerous surveys released every month. A reward system was also suggested by the respondent, as an option to encourage participation but this option raised many ethical concerns and was not pursued during the study.

Limited knowledge on $ETCO_2$ was stated as a concern for participation, by another respondent. There were no ethical concerns highlighted by the pilot respondents, given the information sheet preceding the survey covered the main ethical points for research. Overall the questionnaire was clear, acceptable length (time) but needed some amendment.

3.5.3.2. Modifications made to the survey tool

In order to resolve the Arabic version of the survey tool being opened, a link was created to specifically access the English version of the survey tool through an internal system on the 'Survey Monkey' platform. The gender responses were reduced to male, female, other and rather not say options only. The formal training on $ETCO_2$ was replaced with education exposure to $ETCO_2$ so that any training could be included. The CPR graph that was creating confusion was replaced by a picture of an ECG Monitor with a capnography function and the $ETCO_2$ value on the screen that was highlighted for interpretation. From investigation on the CPR cases and capnography use, it was found that EMTs were using the 'Metronome Function' in resuscitation attempts. As a result they were not observing the capnography trends therefore they may not have been familiar with the trend initially planned. The $ETCO_2$ value for on the monitor as a quality measure

of CPR, seemed more appropriate given the feedback. Therefore, the image replacement of the CPR trend graph was more user-friendly in the final version of the survey.

The survey was formatted, so that the font was clear, the questions were short and specific. Response options were standardized with options for alternate answers where necessary. The formatting also included forwarding to relevant questions when a leading question was negative. Also, if the responded opted not to participate, then it allowed the responded to skip to the end 'Thank You' note. A separate information sheet had to be created as the survey monkey did not allow for extensive pre-survey information loading. The survey details were sent to the National Ambulance QHSE Department to load on to the licensed survey platform. The statistician reviewed the questionnaire considering accuracy and validity of the questions and suggested minor changes that were incorporated into the survey. Changes in response options standardization, using specific terms, realignment to the objectives and other changes including typo, grammar and spelling being rectified.

3.7. Data Collection Procedure

3.7.1. Analysis of historical records

This three-phase study involved the retrospective analysis of historical data involving patient care and the use of POCT capnography trends as the 2nd Phase, and the subsequent analysis of EMT-B clinical staff's self-perception of inclusion of $ETCO_2$ into their scope of practice as the 3rd Phase. In order to conduct the study within the ambit of National Ambulance due-restriction, clinical staff and data sources, the organizational authorization and support was essential. Permission was sought from the National Ambulance CEO by formal correspondence stating the nature of the study, the aims and objectives and design of the research. Also, other aspects of ethics and nature of information required for the study had to be clarified to ensure fundamental principles of research are adhered to, as well as minimising the risk to National Ambulance as a company and the clients it served. (Annexure B – CEO Letter of Application) attached served as the initial application as reference for the study authorization. Once this over-arching authority was granted then the National Ambulance Research Committee had to be approached to deal with the 'Research Process' and the access to the National Ambulance database for the data required for the second phase review. To this end a detailed 'Letter of Application' was submitted to the research committee, supplemented by a Draft Research Proposal and a comprehensive Table of Data variables that was required for the second phase of the study including some of the correlations that were anticipated. Annexure D (Dataset Requirements Tables), attached serves as reference of the application letter. The table below 'Resuscitation – PAROS Data Requirement'

serves as an example of the type of Data Variables Datasets that was detailed in the application process.

Table 2. Example of Data Variables used in Data collection Procedure

Resuscitation - PAROS Data Requirement

PAROS Variables Dataset	Required for Study	Excluded from Study
Case Number	Case Number	
Date	Date	
Gender	Gender	
Nationality	Nationality	
Location	Location	
Patient DOB	Patient DOB	
Age	Age	
Medical History		Medical History
Estimated Time of arrest		Estimated Time of arrest
Bystander CPR		Bystander CPR
Bystander AED		Bystander AED
Arresst Witness		Arrest Witness
First CPR Initiater		First CPR Initiater
Resus Attemted By EMS/Priv		Resus Attemted By EMS/Priv
First Arrest Rythym		First Arrest Rythym
Time CPR Started by EMS/Priv		Time CPR Started by EMS/Priv
Time AED Applied by EMS/Priv		Time AED Applied by EMS/Priv
Prehospital Defibrillation	Prehospital Defibrillation	
Defibrillation Performed By		Defibrillation Performed By
Medchanical CPR Device used	Mechanical CPR Device used	
Prehospital Advanced Airway	Prehospital Advanced Airway	
Prehospital Drug Administration	Prehospital Drug Administration	
Return of Spon Circ (ROSC)	Return of Spon Circ (ROSC)	
Time of ROSC		Time of ROSC
CPR Discontinued Scene/Enroute		CPR Discontinued Scene/Enroute
Final Status at scene		Final Status at scene
Cause of Arrest		Cause of Arrest
Level of Destination Hospital		Level of Destination Hospital
Patient Stats at ED Arrival	Patient Stats at ED Arrival	
Time of Call Received		Time of Call Received
No First Responder Dispatched		No First Responder Dispatched
Time First Responder Dispatched		Time First Responder Dispatched
Time Ambulance Dispatched		Time Ambulance Dispatched
Time First Respnder Arrived Sc		Time First Respnder Arrived Sc
Time Ambulance Arrived Scene		Time Ambulance Arrived Scene
Time EMS arrived at Patient Side	Time EMS arrived at Patient Side	
Time Ambulance Left scene	Time Ambulance Left scene	
Time Ambulance Arrived at ED	Time Ambulance Arrived at ED	
	ETCO2 Readings (1st & Last)	

KEY
Pan Asian Resuscitation Outcomes Study - Variables in Database
Variables to be Used for BLS Study Purposes
Variables NOT used for Study

An informal presentation to the research committee members (including the IT Engineer) was also convened to clarify a few issues around some of the implications and perceptions of the content in the submitted draft proposal as well as the data requirements for the study.

Eventually, permission was granted by both the National Ambulance CEO and the Research committee.

The next phase in the data acquisition, was the collaboration with the IT Software Engineer that was mandated by the National Ambulance to support the research data requirements. The role of the IT Engineer was to extract the required data (as requested) from the Database. Being a non-clinical person there had to be many mails and collaboration to extract the pertinent variables from the multiple coded fields of the database.

3.7.2 Phase 3 – Survey

The third phase of the study involving the self-perceived value of the EMT-B staff on the $ETCO_2$ use and inclusion into their scope of practice, involved the use of a survey technique. Permission to conduct the said survey was also included in the authorization requests and a preliminary Survey Tool had to also be presented to the National Ambulance Research Committee and is attached as reference (Annexure E – EMT-B Survey Tool on $ETCO_2$). The Questionnaire Survey tool was intended to be based on an electronic format application such as Microsoft Forms® or Survey Monkey® platforms. After trailing the free software on both the platforms, it was found to be inadequate for the purposes of the study in that there were many limitations. Therefore, a separate application had to be to the National Ambulance Medical Director for the use of the organization account Survey Monkey Platform for the purpose of the study (Annexure F – NA SurveyMonkey® Application use).

The design of the survey tool included an introductory and information page in addition to the various categories of Demographic details, Knowledge, Skills and Attitude data-sets. The introduction served to inform the proposed candidate of the nature of the study, the researcher and supervisor's details etc. Further, details Welcome, Purpose and on Ethics was also provided. Also as advised by the supervisor's information on benefits, maintenance of confidentiality and rules of voluntary engagement with the option to withdraw without prejudice had to be clarified and set the tone of the survey. Consent as documented evidence was included as well on the onset of the survey engagement.

In the Demographic category detail on the geographical deployment, job function, age, gender and other pertinent questions were included. In this section the medical crew staff number was also requested and drew significant attention from the research committees vetting the research project. After much deliberation and consultation with advisors it was agreed that the crew staff numbers request could remain in the survey but limited to statistical significance and not used as a tracing parameter which, was duly agreed and acknowledged.

For the Knowledge Section of the survey, the intention was to primarily acquire information on the capnography/ $ETCO_2$ formal and informal education, training and exposure inputs that would

have capacitated the EMT-Bs to deal with the particular point-of-care testing tool. This section was also designed to extract learning opportunities that were afforded to the EMT-Bs in the run-up to the inclusion of capnography into their scope of practice, and would inform 'task shifting' initiatives if applied.

Skill assessments in the subsequent section was limited to a few fundamental uses, and application of capnography/$ETCO_2$ in patient care scenarios. This was included to understand if the basics of capnography/$ETCO_2$ use as advocated by authorities in the EMS, were in compliance, and also identify any gaps if there were any. This section also spoke to the level of preparedness and retained knowledge on the subject of capnography in the current setting and, could serve to plan going forward in quality improvement endeavours. In order to maintain participation in the survey, capnography samples were limited to four only, with a few related questions on each of the basic capnography samples pertinent to EMT-B level of care. Lastly, in the attitude section of the survey questions pertaining to the perceptions of inclusion of the technology in to the EMT-B scope, usefulness, ease of use and perceived values were incorporated to the survey to cover the objectives of the study.

3.7.3. Extenuating Circumstances in Data Collection Process

In order to determine the number of staff available locally at the time of the survey roll-out, information on staff allocations and staff availability had to be considered. The number of staff voluntarily participating may have also been affected by local circumstances of the survey time -period end 25 December 2020 – 25 January 2021.

The extenuating circumstances to be considered, are as follows:

a. Staff experienced salary reduction and contract changes and were despondent at the time of survey roll-out (December 2020).
b. The 'Second Wave Covid-19 Pandemic' caseload (escalation of Covid-19 Patient responses) and staff were exposed to high stress environment, an increased in sick leave was noted.
c. The release of 'DOH Learning Activities' (10 Programmes) in 90 Days (starting 07 January 2021) as compulsory assignments, was considered priority over voluntary activities.
d. Many EMT-B staff were on sick leave due to Covid-19, and resulted on increase in workload for residual staff, with limited rest periods. Therefore, the voluntary survey was not priority.
e. Decontamination of ambulances and equipment after each case (increased workload) & pressure on turn-around times contributing to time and stress.
f. The Ministry of Interior (MOI) client audit pressures (Daily Monitoring of Scene Times & Hospital turn-around times) also impacted on stress and workload.
g. Release of other QHSE surveys and activities (concurrently with $ETCO_2$ Survey) Waste Disposal Survey, Annual QHSE Training Refresher, Information Technology Security

Update Release, Peer Support (Staff Support Program). Therefore, the priority of survey was less likely.

h. The increased 'Events Coverage' and need for 'Cover Staff' (Multiple Events x 3) – increased workload significantly for staff that were available.
i. Time period between December to January are the busiest time of the year. Christmas & New Year Occasions. Therefore, the release of survey timing was not ideal. (Poor timing – Official Release) through a que system that was not ideal.
j. Rest, Staff Operational Meetings, Overtime & Education Training (Online & Physical) on Days-Off (time availability) was decreased.
k. Staff available to participate in study survey was considerably reduced to 382 EMT-Bs.

Table 3: Table of EMT-B Staff allocations & availability (January 2021)

Base	No of EMT Staff	No of Ambo's (Avg.)	Staff on Vac Leave (Jan)	Staff on Sick Leave (Jan)	Region	Liaison
Sharjah - Kuwaiti	58	7	7	8	Area 4	Area Team Leads
Sharjah - Muwailah	58	7	6	8		
Ajman – Main Station	69	8	7	5	Area 3	Area Team Lead
Ajman – Manama	34	4				
Ajman - Madam	32	4				
Fujairah – Dibba	25	11	6	4	Area 1	Area Team Lead
Fujairah – Khor Fokkan	70					
Ras-Al-Khaimah	93	10	4	2	Area 2	Area Team Lead
Umm-Al-Quwain						
Excl. Admin	-					
Excl. Drivers & EMT-I	-					
Total	439	51	30	27		Avail. **382** Staff

The intention was to include the entire population of 438 EMT-B staff in the survey. However, due to some logistical reasons (e.g., staff on sick or vacation leave during the survey period, and the limited window during which the online survey could be kept open and follow-ups made), as well as the voluntary nature of participation, total number of responses received was 281 out of 382 available staff at the time of survey, for a response rate of 74.56%. This was considered a reasonably good response rate under the circumstances.

3.8. Data Processing and Analysis

Phase 2 – Some of the required outcomes from data mining process (Annexure I) from Patient Records in database included the following:

a. Determine (Daily, Monthly & Study Period) Emergency case load per demographic area to allow for breakdown of analysis into these time periods for comparison.
b. Establish the number of various case pathologies recorded over the time period that is area specific to help identify bias in case pathologies and resource allocations.
c. Establish actual $ETCO_2$ utilization trends over the retrospective period aligned to pathologies to establish utilization bias.
d. Determine the general trends of use to establish the overall view of the variables.
e. Establish potential opportunities for $ETCO_2$ in pathologies where it was not used.
f. Establish (information gaps) questions for inclusion in the survey.

3.8.1. Determining Emergency Case Load per Demographic Area was achieved through:

3.8.1.1. Geo-graphic case load Stratification (Daily. Monthly, 12-month period) of the geographical areas involved for comparisons and establishing bias.

i. Sharjah Emirate
ii. Ajman Emirate
iii. Ras-Al-Khaimah Emirate
iv. Umm-Al-Quwain Emirate
v. Fujairah Emirate

3.8.1.2. The number of resource allocations to each region (extracted separately) to compliment the demographic data achieved in the primary analysis was attained from NA Management feedback. This helped to correlate to results from the survey.

i. Ambulance
ii. Staff
iii. Back-up support

3.8.2 The number of various case pathologies recorded over the time period was established under the categories below and was also stratified according to regional areas. Capnography is considered to have some value in the pathologies are analysing these variables can help distinguish where it was appropriately used and potentials for use.

3.8.2.1. Head Injuries
3.8.2.2. Respiratory Injuries
3.8.2.3. Trauma Injuries
3.8.2.4. Psychiatric Emergencies
3.8.2.5. Resuscitation Cases
3.8.2.6. Other Categories

3.8.3. The actual $ETCO_2$ utilization over the retrospective period aligned to pathologies was established through:

3.8.3.1. Mining the $ETCO_2$ use data, according to pathologies (NA Coding) Working Diagnosis.
3.8.3.2. Differentiating between $ETCO_2$ use / non-use for same category clinical pathologies highlighted usage trends and opportunities.
3.8.3.3. Establishing the number of crew using $ETCO_2$ per region ($ETCO_2$ & Crew Tracking)
3.8.3.4. Identifying potential pathologies numbers for $ETCO_2$ use "Gaps'' (Pathology Tracing)
3.8.3.5. Comparing regional trends (from $ETCO_2$ usage trends)
3.8.3.6. Establishing patient contact time where $ETCO_2$ potential (Pathologies, At Patient time and at Handover time)

3.8.4. $ETCO_2$ use trends in Cardiopulmonary Resuscitation (CPR) was established through analysing the following variables with the outcome being discussed in the discussion of the results. The following comparisons help to determine the use and benefits of Capnography in Cardio-pulmonary Resuscitation (CPR) cases.

3.8.4.1. $ETCO_2$ used with CPR
3.8.4.2. $ETCO_2$ used with CPR + SGA's
3.8.4.3. $ETCO_2$ used with LUCAS Compressor
3.8.4.4. $ETCO_2$ used with CPR + ROSC
3.8.4.5. $ETCO_2$ used ≤ 10 mmHg $ETCO_2$ (initial) with CPR
3.8.4.6. $ETCO_2$ used ≥ 10 mmHg $ETCO_2$ (initial) with CPR
3.8.4.7. $ETCO_2$ used ≥ 20 mmHg $ETCO_2$ (initial) with CPR
3.8.4.8. $ETCO_2$ used with Increasing $ETCO_2$ trends (with or without ROSC)
3.8.4.9. $ETCO_2$ used in CPR with No Readings / Atypical Recordings
3.8.4.10. $ETCO_2$ used with post-resus monitoring

3.8.5. General trends of $ETCO_2$ use (incl. Bias) and also non-use was established in the following ways:

3.8.5.1. Based on identified pre-hospital uses of capnography, to establish which pathologies $ETCO_2$ could have been used (Lost Opportunity) but was not.

i. Pathology Codes with no $ETCO_2$ data captured on patient reports, indicating non-use.
ii. Patient Contact Time recoding analysed – to highlight time opportunity for use of $ETCO_2$ that medical crew had exposure to.

3.8.5.2. EMT-B Crews use of $ETCO_2$ based on ID related correlation to $ETCO_2$ recording on patient records.

3.8.5.3. Bias in use for Pathologies ($ETCO_2$ use vs non-use trends for identified pathologies) was determined by correlation of the following variables:

i. Area specific ($ETCO_2$ + Pathology + Area Trends)
ii. Crew specific ($ETCO_2$ + Pathology + Crew Trends)
iii. Contact Time specific ($ETCO_2$ + Patient to Handover time)
iv. Medical vs Trauma Specific ($ETCO_2$ + Category Trends)
v. Pathology Specific ($ETCO_2$ + Pathology Codes Trends all areas)
vi. CGS Specific (LOC) ($ETCO_2$ + GCS Scores)
vii. Adjunct use specific ($ETCO_2$ use + Nasal cannula / SGA use)

3.8.6. Trends & Gaps Identified from the above will be further explored in the Survey Questionnaire (Phase 2) of the study.

Table 5: An example of data variables (Univariate) correlation planning in the design phase.

Associations & Correlations				
Variable 1	**Values**	**Variable 2**	Numerical Value	**Correlation Value**
Base Station Allocation	Discrete	EtCO2 Recoding	Discrete	Indication of Demographic Use ETCO2
Head Injury	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Head Injury Patients
Respiratory Pathology	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Respiratory Patients
Respiration Rate	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Respiration Rate calc.
Working Diagnosis / Code	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for specific Pathologies (like Asthma)
OP/NP	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for patients with decrease LOC
BVM	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use as guide for BVM application
Shock Index	Continous	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Shock Index Patients
Time CPR Started EMS/Private	Continous	EtCO2 Recoding	Discrete	Indication of ETCO2 use in Resuscitation
Mechanical CPR Device used	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Resus with Mechanical Device
PreHospital Advanced Airway (SGA)	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for SGA Placement
Triage Category	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use according to Traige Rating
Return of Spontaneos Circulation	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Return of S Patients
At Patient Time	Contionous	Arrival at Hospital Time		Indication of Total Patient Contact Time
Time EMS Arrived at Patient side	Continous	Time Ambulance Arrived at ED		Indication of Resuscitation Contact Time
Base Station Allocation	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$
Head Injury	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Head Injury
Respiratory Pathology	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Respiratory Pathology
Respiration Rate	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ to assess Respiratory Rate
Working Diagnosis / Code	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ accoding to Working Diagnosis
OP/NP	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Obtunded Patients
BVM	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for patients being Assist Ventilated
Shock Index	Continous	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for patients in Shock
Time CPR Started EMS/Private	Continous	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for duration of Pt. contact time
Mechanical CPR Device used	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for measuring Quality of CPR
PreHospital Advanced Airway (SGA)	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Confirming placement of SGA
Return of Spontaneos Circulation	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ and association with ROSC

KEY
Variable 1 to be Correlated to Variable 2
Variable 2 to be Correlated with Variable 1
Result of Correlation between Variables 1 & 2

Table 6: An example of secondary analysis (Multivariate) correlations design planning.

Mulitple Correlations					
Variable 1	**Variable 2**	**Variable 3**	**Variable 4**	**Variable 5**	**Value of Correlations**
Head Injury (Coding 12)	Respiratory Pathology (Coding 05)	Resuscitation (Coding 06)	Shock (Coding 04/ Uncoded)	Other Diagnosis (Coded)	An Indicator of Pathology Bias
Male	Female				Indicator of Gender Bias
Ajman	Sharjah	Umm-Al-Quwain	Fujairah	Ras-Al-Khaimah	Regional Bias (use / Non-Use)
CPR	Mechanical CPR	ETCO2	ROSC		Different. ETCO2 Val. Mech vs. Normal
CPR	Pre Hospital Drug Therapy	ETCO2	ROSC		Drug Therapy Ass with ROSC
CPR	PreHos. Adv. Airway	ETCO2	ROSC		Adv Airway vs BVM Values
CPR	ETCO2	ROSC			ETCO2 Ass with ROSC Highlight
CPR	No ETCO2	ROSC			Quality of CPR Lost Opportunity

KEY
Variable 1 - Head Injury
Variable 2 - Respiratory Pathology
Variable 3 - Resuscitation
Variable 4 - Shock
Variable 5 - Other Working Diagnosis
Result of Correlation (V1-V5)

3.9. Internal and External Validity:

The study outcomes do have internal validity, considering that it included the total population of EMT-Bs in the geographical area of study. National Ambulance staff working in the northern emirates area accounted for the majority if not all of the study population, so it has validity for the geographical location representivity. Also, the national Ambulance is the primary provider of services for government, it is therefore valid to the government in that due-restriction (northern emirates). Further, that five (5) of the total seven (7) emirates of the UAE are included in the study, it has implications for the entire UAE as a country.

There are inferences for external validity, for organizations with similar circumstances and areas operations or settings. In the Middle Eastern and North African Region (MENA) beside the geographical area being of similar terrain and environmental factors. EMS services are in their infancy and any trend or lessons from the neighbouring countries may serve to inform local services in the region (Moafa, *et al*., 2019)

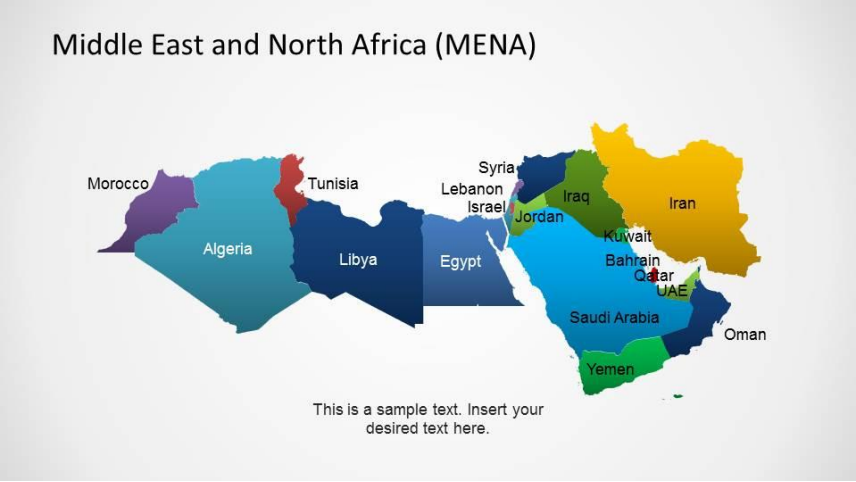

Figure 6: MENA Region Illustration

Beyond the MENA Region, this study has implication for EMS services on a global scale. If POCT capnography can be successfully implemented at EMT-B level, then there is opportunity for the mass EMS EMT-B staff to follow suit. The overall implication on patient care quality may be significant but, is yet to be tested. At the current stage the main aim of the study, was to answer the question of ''How does point of care testing (POCT) through capnography, enhance the diagnostic capability of EMT-Bs in the UAE?'' This information could help other EMS inform their position on the subject. If anything, the study will raise awareness on capnography as a POCT tool in general. It also highlights to other EMS services around the world on the possibilities of task shifting to frontline staff.

3.10. Ethical Principles

Principles of beneficence and non-maleficence, equity and respect underpin the study. The ethical norms and standards prescribed by Ethics in Health Research Policy of South Africa (2017) have been used to guide the study, (Wikler, 2010). The scientific integrity, study design and methodology are based on credible literature sources as guidance. The process is also overseen by research supervisors as well as examined by the university appointed research capable specialists. Therefore, the study in compliance with ethical and moral and core values aligned to the organizations and people that are involved in the process.

It must also be noted that some of the main focuses of the study was to contribute toward the quality improvement of current systems in EMS. The other driver being, the consolidation of the research process as a learning event in a master's qualification process. As a primary stakeholder in the study, the CEO of National Ambulance has requested the right to reply to the final document outcomes.

3.10.1. Institutional Ethics Clearance/Approval

National Ambulance CEO Approval (Annexure B – CEO Application Approval) attached.
At the very outset of the study process during the conceptual phase, permission had to be sought from the National Ambulance otherwise, the study would not have been able to be conducted. One of the challenges being that, National Ambulance is a governmental organization and is regulated by strict laws with little tolerance for abuse of power, in this case information. Therefore, meetings were convened with National Ambulance senior management (with research experience) where, a detailed proposed study protocol was presented. Emphasis was placed mainly on the nature of the study and it was reviewed to determine the implications of the study on the Organization, the Government and the Country. After a few amendments and agreements, the senior management made their recommendations to the CEO, who subsequently approved the study at National Ambulance and also access to using the organizations patient care records. Annexure C (NA Research Committee Application), is attached as reference. National Ambulance Research Committee Approval (Annexure G – NA Research Committee Application Approval) attached as reference.
In a parallel system, the Cape Peninsula University of Technology appointed the supervisors for the study and the Ethics Committee application process was released through the Student Support portal. The Ethics Application was completed and submitted online. The application was considered by the expert panel of the institution ethics committee members and later approved for continuation of the study after a few amendments. The Ethics Committee approval (Ref. CPUT/HW-REC 2020/H9 is attached as Annexure A – CPUT Research Committee Approval) as reference.

3.10.2 Risk of Group Harm

3.9.2.1. The EMT-B Group is the only group participating in the study. There is no anticipated harm, rights or welfare that will be infringed on, by course of the study. If anything, the study is being conducted to support the EMT-B group if there are any gaps identified. Risks are considered to be minimal due to the retrospective nature of the data being used in the second phase. The third phase of the study involved voluntary participation in a survey that maintains anonymity and confidentiality. Active prospective patient care did not form any part of the study and therefore risks to patient care was minimal. Also, due to no prospective pharmacological, equipment, or procedure testing in active patient care, adverse events or effects were not anticipated. However, if there were any, it would have been reported to the investigator or line supervision and there were mechanisms in place to support staff. National Ambulance have in-place the Research Committee, Peer Support Groups, Quality, Health and Safety (QHSE) Reporting System

that could help deal with any adverse event if required. The accessibility to support systems if required was made available online through reporting to the Quality, Health and Safety System with a 24-hour response time. If any adverse event of a serious nature was experienced, it could have been dealt with immediately with the management systems in place.

The group risk (study cohort) of poor performance possibility, with minimal uptake of $ETCO_2$ use uptake was considered. Although, the implication may be negative on the onset (if the findings were such), this would not have been viewed in a negative manner and would not affect staff performance assessments in any way. It has been agreed by National Ambulance management that the study was meant to highlight the positive and negative components of the capnography introduction, so that if there were any gaps in the process, it could be addressed to make the capnography use sustainable in the long term, and would also serve to improve on quality of patient care offered in the UAE. Capnography is viewed as an innovation, and introducing this POCT tool at EMT-B level is certainly and accolade for local EMS services in leading the fraternity and participants would be acknowledged for their positive role in this initiative.

3.10.2.2. Some of the other anticipated benefits included the following:

- The creation of a 'bottom-up' perspective of EMT-Bs Clinical Practice level entails given the education and training, scope of practice and resource availability.
- The determination of the diagnostic abilities of EMT-Bs to provide emergency care services as per the professional / institutional guidelines given the available tools to do the job.
- Highlight of the additional tools/point of care recommended tests that are safe to implement, and support EMT-Bs to provide care with greater efficiency.
- The highlight of standards of diagnostic tests and parameters, that international stakeholders have recommended for enhanced patient care.
- Attention is drawn to the process of extended EMT-B scope of practice that informs better implementation and outcomes.
- The provision of evidence to guide greater support for EMT-Bs in caring for patients in emergency care situations.

3.10.3. Ethical Considerations

As a National Ambulance employee and undertaking a study within the organization it is acknowledged that the ethical considerations need to be taken into account at the very onset and throughout the study process. As the principal investigator, care was taken not to directly engage with frontline EMT-Bs that were involved in the study. Also being an Advanced Life

Support (ALS) practitioner in the system, the study focus excluded the advanced level of care related to capnography and diagnostic ability or operational functioning. The added advantage of not representing management, nor clinical operations in the study helped to maintain neutrality. Also, having exposure to the education system but not currently being involved in training allowed for independent review of capnography education and training exposure. National Ambulance ethics clearance from National Ambulance Research Committee was also granted (Annexure G) after interrogating the ethical considerations. The management did not interfere in the research process, nor influence any process and were supportive of the study. There was no pressure to account to management on the results of the research other than the research ambit and processes. However, management did request the right to respond to any matters that may arise out of the research from an organizational point of view. Focus on the research process oppose to outcomes was the primary goal of the research. As a researcher declaration of interest, it must be recorded, that there was no conflict of interest.

3.10.3.1 Relevance of study

Capnography use as a POCT in the UAE at EMT-B Level was not clear in terms of ability, use, safety, regulation and patient care. The study was used to inform these parameters to advocate safe practice, that guides the practitioner and support patient care in the EMS setting. The value of the study is far reaching as it could serve to inform other EMS organizations in terms of POCT capnography implementation, safe usage, policy and procedure and audit of patient care. The study is beneficial to the practitioner, EMS system and the patient (Basis, 2009). In current times with the advent of new technology and portability of $ETCO_2$ monitoring devices, this type of monitoring is more accessible and also cost effective. Like all new technology introduction, there needed to be a process to facilitate the transfer of knowledge in order to gain effectiveness of the tool introduced. (Turpin, Woolley and Marceau, 2010).

3.10.3.2 Role Player Engagement

All role-players involved including participants was engaged in the study. The research process was constantly overseen and advised by supervisors, statistician as well ethical and management committees given approved processes and oversight at the appropriate intervals.

3.10.3.3. Fair Selection of Participants

The study included the entire study population of four-hundred-and thirty-eight (438) participants, by invitation. However, all did not participate. A critical value of 250 participants minimum (as calculated by the sample size requirement) was required to produce significant findings and the randomization method was not used. The implications of these decisions are reported in the results discussion.

3.10.3.4. Fair Balance of Risks and Benefits

In the phase of the database review of the patient care records that was digitally mined, there was minimal risk anticipated as the data was retrospective. So not impacting on patient care or staff involved minimized the risk. The benefits of this phase of the study identified utilization trends and gaps and was used to inform future practice and implementation enabling the practitioner for higher patient care quality.

The third phase of the study was prospective but did not involve patient interaction or any participant clinical activity. The study was limited to a survey response only. The benefit on the other hand was to support patient care and the participant, congruent to the participant perception of their needs.

3.10.3.5. Informed Consent

Consent for the data retrieval was sought from National Ambulance, participants in the survey were voluntary and consent was sought prior to the study commencement. No personal patient information or clinical interventions was required for the study.

3.10.3.6. Ongoing Respect (Privacy & Confidentiality)

The participants of the study reserved the right to withdraw from the study process at any time. Also, the participant information was treated with strictly confidentiality and no individual tracing was conducted. The staff decision not to participate or withdraw from the study and anytime was made clear to the participants on the survey information sheet, that also stated that their decision would be respected and be without prejudice. This declaration may have influenced the lack of participation by some staff and may account for some of the drop-out rates.

Privacy and confidentiality from the patient record information reviewed in the historical data collection did not contain any patient personal information, so patient privacy in the retrospective data-sets was maintained. In terms of the security of the data-sets acquired, they were stored electronically and was password protected. Only the researcher and statistician had access to the relevant data (that they were dealing with at any one particular time). It was also agreed by National Ambulance management that the datasets on completion of the study, would be deleted. The survey response was conducted on an electronic survey platform that was overseen by the National Ambulance Research Manager and was also password protected.

3.10.3.7. Researcher Competence and Expertise

The Research study was supervised by well-established and recognized researchers of sound research standing from Cape Peninsula University of Technology. The process and content of the study was informed by rigorous literature reviews and based on clinical best practice guidelines. Lastly, an external examiner was used to determine if the process, content and quality of the study is of a satisfactory level.

3.10.4. Bias

Understandably, bias could happen at any stage of research and there was a need to be cognisant of these in order to avoid them. Some of the considerations for this study was to acknowledge and avoid bias as follows:

3.10.4.1. Selection Bias - In order to avoid selection bias for the study, the entire population was invited to participate (approx. 438 EMT-Bs). Therefore, a higher quality feedback and decreased selection bias was expected. The study results were also not generalized for the entire UAE Population, rather the detail was contextualized to the finding of the particular geographical area of study.

3.10.4.2. Culture Bias – majority of the EMTs employed at National Ambulance were from the Philippines. There were no interview process and the study limited to self-directed questionnaires to gain information, so cultural bias may be acknowledged. Other forms of cultural bias in terms of responses or electronic database trends were considered and reported in the discussion.

3.10.4.3. Confirmation Bias – When a Hypothesis or Idea of the study is formed and the researcher makes all efforts to consolidate that particular view-point while neglecting

other evidence that may be contrary to the particular view taken. (Sarniak, 2015). In this study there was no hypothesis to be proved. Also, there were no particular view-points that are taken oat the onset, rather it was explorative and descriptive. There were questions and objectives to be met but the study was expected to reveal the answers to the questions without researcher manipulation. All study feedback and analysis were preserved as evidence to the study.

3.10.4.4. Data Collection Bias – Data was collected from the EMS Electronic Database and a Questionnaire Survey method. These tools used were subjected to Ethical Committees and the University approvals. The results and discussion are evidence based with raw data retained as evidence. A Statistician was also employed to guide the process and reduce bias. Factors such as Question Order Bias, Wording Bias, and Leading Questions were considered in the construction of the survey tool.

3.10.4.5. Recall Bias – The plan to manage this type of bias was to gain a current view of the practitioner's responses. While there were some questions that required retrospection, it was be limited to a twelve-month period. A huge portion of the retrospective data used in the study was collected from the electronic database which, had limited bias.

3.10.4.6. Sponsor Bias – Did not apply in this particular study. It must also be stated that the researcher had no financial disclosures other than part-requirement for the qualification requirement. The study was emphasis was on research process opposed to results or outcomes although this was given equal importance. Therefore, there were no researcher gains from the study outcome, financially or otherwise.

3.10.4.7. Performance Bias – The study did not involve physical observations, or clinical trials or treatment regimens and therefore performance bias was limited. The electronic data from the database was also retrospective, so this type of bias was somewhat limited.

3.10.4.8. Citation Bias – Reporting on only selected article supporting the hypothesis or ideology has already been eluded to in 'Confirmation Bias's and was controlled by consulting a comprehensive database research articles/information on the study. Also, subject matter experts will be involved in supervising the study to limit skewed reporting. This type of bias was also related to researcher ethics which was guarded against.

3.10.4.9. Confounders – some confounders to capnography use were variables such as Time factor, Clinical priority, Operational, Clinical or Management support etc; these were factored into the survey and was considered in the analysis and interpretation and was reported. Other confounders were discovered from the feedback and included in the reporting and discussion.

3.9.10.10. Internal vs. External validity – the study outcomes do have internal validity, considering that it included the total population of study in the geographical area for the local organization. There are inferences for external validity, for organizations with similar circumstances and areas operations or settings. The main aim was to answer the question of ''How does point of care testing (POCT) through capnography, enhance the diagnostic capability of EMT-Bs in the UAE?'' This information could help other Emergency Medical Services inform their position on the subject.

3.11. Summary

The design and methodology adopted for the study was relevant and in-keeping with best practice (Wikler, 2010; Kumar Ranjit, 2019) and other studies of a similar nature (Wylie, Welzel and Hodkinson, 2019). However, the current study was more comprehensive in nature and the time, sample size and process investment were expected to produce a higher quality result. Being a multi-phase study, the historical data phase had to be completed, before the third phase commenced. By design, the planning was to allow for gaps in information relevant to the objectives of the study, to be covered in the survey as a second phase to provide a more comprehensive report.

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Chapter 4 – Results

4.1. Introduction

The National Ambulance electronic database has 80 708 cases that were serviced for the 12-month period spanning 01 March 2019 to 29 February 2020. Of these, 18 211 cases were cancelled for various reasons, and are excluded in this sample. Only case pathologies, that may have clinical significance to $ETCO_2$ (and within the study period) was considered (N = 39 937) for inclusion in this study (Annexure I). In the literature there is strong evidence for use of $ETCO_2$ in certain scenarios such as Head Injuries (Grayson, 2016), Respiratory Monitoring (Nagler and Krauss, 2009), Placement confirmation of Endotracheal Tubes (Link, *et al.*, 2015) and Resuscitations (Donald and Paterson, 2006) were advocated. There are many emerging uses for other clinical scenarios (Aminiahidashti, *et al.*, 2018; Basis, 2009). Therefore, this study draws attention to the $ETCO_2$ significant pathologies alluded to in previous research. Particular attention is drawn to the use of the $ETCO_2$ by EMT-Bs at the northern emirates of UAE. The study reviews historical data for geographical trends, pathological (Head Injury, Trauma, Respiratory and Ventilation, Cardiopulmonary resuscitation (CPR) trends, $ETCO_2$ utilization and non-utilization trends and also identifies opportunities for $ETCO_2$ use.

In the third phase of the study emphasis is placed on demographic detail of the participants as well as the knowledge, skills and attitudes of the attending EMT-Bs in the northern emirates of UAE. The knowledge component tries to identify the education, training and exposure to the Capnography / $ETCO_2$ that the participants of the survey were supported with, in preparation for this type of POCT assessment capability. Secondly, the skill component tries to assess some of the knowledge interpretation and cognition in given scenarios that affect patient care as an indication of the participants' ability to use POCT $ETCO_2$ and also speaks to safety aspects of capnography use. Thirdly, information on the attitudes of the participants regarding $ETCO_2$ use help to inform possible reasons for use or non-use of $ETCO_2$. The survey and historical data indicate need for further support and skill sustainability and documents the practitioner view of capnography being added to the EMT-B scope of practice.

The results observed from Phases 2 and 3 of the study were critical to the discussions of capnography use and the implications of it being an enhancement of scope practice at EMT-B level in EMS in UAE. The results were further elaborated in the discussion section (Chapter 5).

4.2. Phase 2 - Retrospective data $ETCO_2$ Trend Analysis Results

The results in Phase 2 are based on the retrospective data held at National Ambulance database. The National Ambulance provides exclusive EMS coverage of the northern emirates of UAE.

Results are presented for $ETCO_2$ potential cases as per demographic regions. Case pathologies include general case trends, Head Injury, Respiratory, Trauma and Resuscitation cases as main areas of interest. Psychiatric and other clinical cases are also considered as future interests given the rapid nature of POCT clinical advancements in EMS. Trends of $ETCO_2$ use are of particular interest, as it speaks to the current trends of current and future EMS $ETCO_2$ use.

The data analyzed in these results were collected from Patient Care Records (PCR) of which, some lacked information on the emirate that the patient was picked-up in, therefore a title of 'Non categorized' is included in the subset. The total number of cases extrapolated from the database with the potential for $ETCO_2$ use amount to 39 937 for the period of study: 01 March 2019 to 29 February 2020.

4.2.1. Determining Emergency Case Load per Demographic Area

The northern emirates area includes Sharjah, Fujairah, Um-al-Quwain, Ras-al-Khaimah and Ajman Emirates. These are 5 of the total 7 emirates, that make up the UAE. Of particular relevance is that the various emirates differ in size, industrial development and population. Sharjah Emirate being the most industrialized (in northern emirates) with a corresponding large workforce of approximately 1.5 million people (EDS Digital Marketing, 2020). As a guide, the following population statistics may lend perspective to the results (EDS Digital Marketing, 2020).

UAE Emirate	Sharjah	Ajman	Ras-al-Khaimah	Fujairah	Um-al-Quwain
Population	1.51 million	0.54 million	0.39 million	0.25 million	0.08 million

Table 7: UAE Emirates in the north population distribution (ref: EDS Digital Marketing, 2020)

4.2.2. Geographic Case Load Stratification: 01 March 2019 -29 February 2020

Table 8: Geographic case load stratification

Emirate	Cases
SHARJAH	17685
AJMAN	8495
RAS AL KHAIMAH	5619
NON-CATEGORISED	4029
FUJAIRAH	2992
UMM AL QAIWAIN	1117

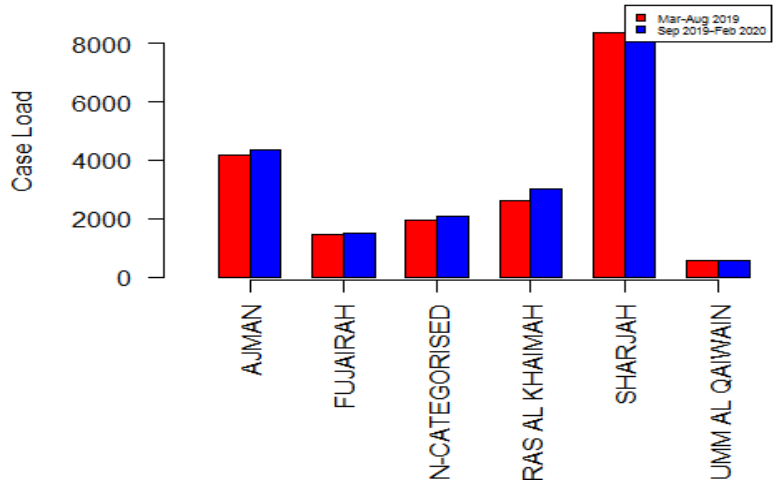
4.2.3. Geographic Case Load Stratification Seasonal Variation Graph

March, April & May represent the spring season while June, July and August are summer months with high temperature ranges. Although outdoor activity is limited because of the extreme heat, work still has to go on. During summer intense labour activity in the outdoors is prohibited by the UAE government in the industry sector from 12h30 to 15h00. These time exemptions for work were enforced from the 15th June to 15 August 2019 (United Arab Emirates, 2015). The autumn and winter months from around September to March brings in the cooler temperatures to the desert area and allows for much more outdoor activity and tourism. This seasonal variation is represented in the findings[9].

The graph representing the case load stratification between the 1st and 2nd halves of the year highlight the slight elevation in caseloads during the winter months, normally a period of greater outdoor activity and increased work times.

[9] Therefore, 12 sequential months were included to mitigate seasonality.

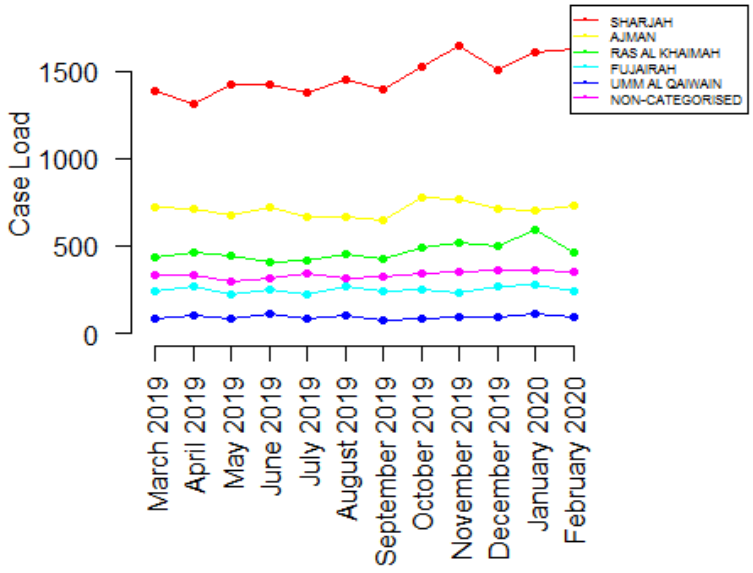
Graph 1: Seasonal Variation Graph: Summer vs. Winter months in the UAE.



4.2.4. Geographic Case Load Stratification: Monthly

The monthly stratification of the caseload shows the increased activity during the November, December and January periods. A slight dip in caseload over the December period is not researched. However, with the large expatriate workforce and the school winter break, many families tend to leave the UAE, to visit family over the Christmas period back in their home countries (Hayley Skirka, 2019).

Graph 2: Geographic Case Load stratification (monthly).



4.2.7. Determining Case Pathologies

The following table is limited to totals across the five specified emirates (Sharjah, Ajman, Ras-al-Khaimah, Fujairah and Umm-al -Quwain) for case categories that have been included in the dataset with relevance to $ETCO_2$ during the specified time period 01 March 2019 to 29 February 2020. All categories of trauma, the unconscious patients and patients where there is potential for respiratory compromise or a need for ventilation was also included as $ETCO_2$ monitoring when assisting ventilation or even monitoring patient ventilations is useful (Bucher and Cooper, 2018). Filtering was done through the 'Patient Diagnosis' field search for the relevant pathology category as per the table below (Table 9). The table highlights the caseloads that EMT-Bs in northern emirates are exposed to over a 12-month period and provides an indication of exposure potential for POCT-related $ETCO_2$.

Table 9: Caseload Pathologies in recorded in dataset

Patient Diagnosis	Case Load
Motor Vehicle Accident (MVA)	10554
Sick (Unknown)/Other	7545
Assault/Trauma	4762
Falls/Accidents/Pain	3940
Unconscious/Unresponsive/Syncope/Weak	2762
Breathing Difficulty	2424
Mental/Emotional/Psychological	2059
Head/Neck	1944
Seizures	1335
Cardiac Arrest	749
O.D./Poisoning	554
Stroke (CVA)	432
Burns - Thermal/Electrical/Chemical	308
Environmental/Toxic Exposure	266
Anaphylaxis	179
Drowning/Near Drowning/Diving or Water-related Injury	83
Infectious Disease	35
Deceased	3
Paediatric Emergencies	1

4.2.8. Head Injuries Cases

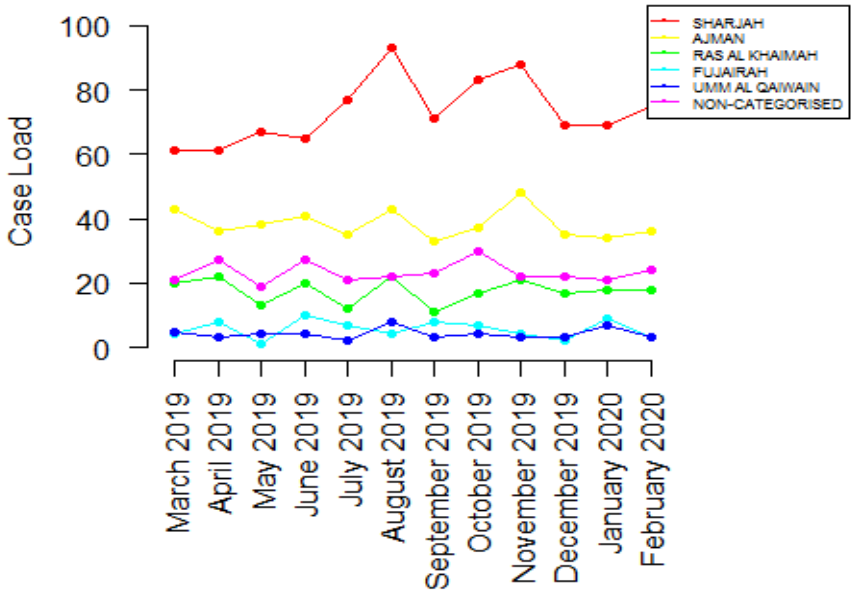
The following data was collected using the National Ambulance code 12 (Annexure H) (Head/Neck) in the '*Patient Diagnosis'* column from the Patient Care Record (PCR) database. The following details relating to potential Head Injuries are the totals by region for the study period. It must be noted that in the filtration process from the database Head and Neck injuries are categorized together in a single code (12), Annexure H serves as reference of the National Ambulance coding system. $ETCO_2$ monitoring in patients that have Traumatic Brain Injury (TBI) is shown to have relevance in monitoring and patient management in the EMS setting. It must be acknowledged that all cases in this category, do not result in TBI or severe neurological deficit. Therefore, $ETCO_2$ may only be warranted for a portion of the 'Head & Neck category' case load which remains undetermined. However, the Head & Neck Injury case load does provide an indication of prevalence as well as opportunity for $ETCO_2$ monitoring of these cases in the northern emirates

Table 10: Head Injury caseload stratified per region

Emirate	Case Load
SHARJAH	879
AJMAN	459
NON-CATEGORISED	279
RAS AL KHAIMAH	211
FUJAIRAH	67
UMM AL QAIWAIN	49

The following table gives the monthly totals of Head and Neck injuries by region. This graph highlights the regional caseload as well as the seasonal variations. It is noted that during the summer months (except for the dip in September) there is an increase in head and neck injury cases. The case load in Sharjah Emirate is significantly higher than the other emirates which is in-keeping with the population size. The case load of the other emirates aligns to population sizes and prevalence of head and neck injury cases.

Graph 3: Head Injury regional caseload graph monthly trend.



4.2.9. Respiratory Cases

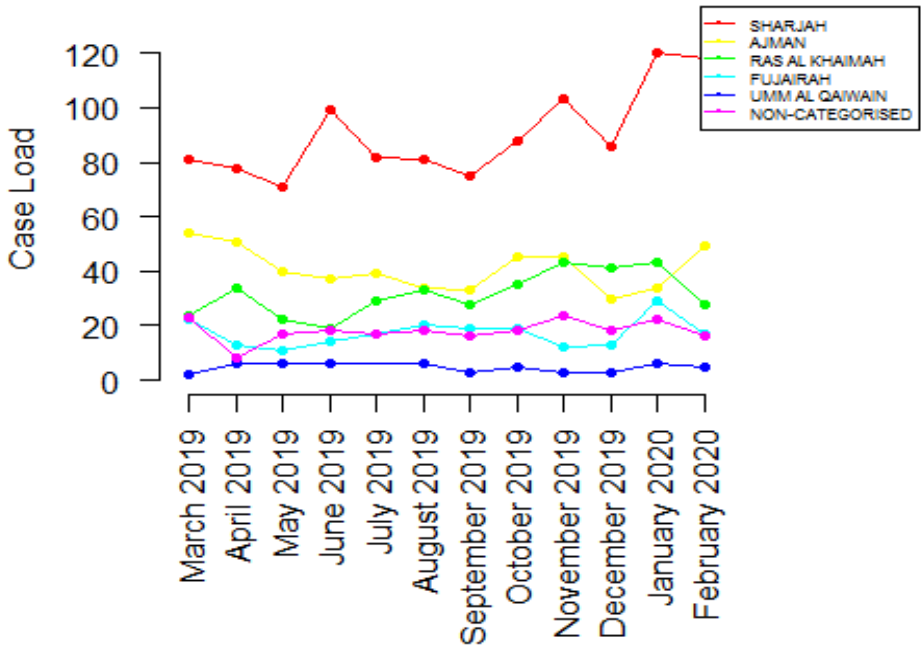
The table data was derived from the National Ambulance database using the NA Code 05 (Breathing Difficulty) from the '*Patient Diagnosis'* field of the Patient Care Records (PCRs). The following are the totals of Respiratory Difficulty cases by region for the study period. These caseload figures also seem to align to the regional population sizes (Fig. 4).

Table 11: Respiratory pathology regional caseload table

Emirate	Case Load
SHARJAH	1082
AJMAN	491
RAS AL KHAIMAH	379
NON-CATEGORISED	215
FUJAIRAH	206
UMM AL QAIWAIN	51

The following table gives the monthly totals of 'Respiratory Difficulty' cases by region; this information is then summarized in a line graph. The graph representation compares the general trends by region. Also highlighted are the escalation of respiratory difficulty in the cooler months of the year (November to February).

Graph 4: Respiratory caseload graph with monthly trend.



4.2.10. Trauma Cases

The following data was extracted from the National Ambulance database code 21 (Assault/Trauma) from the *Patient Diagnosis* field of the Patient Care Records (PCRs). The following Trauma Cases are the totals by region for the study period and is reflective of the case-loads.

Table 12: trauma cases regional stratification table.

Emirate	Case Load
SHARJAH	2317
AJMAN	1201
RAS AL KHAIMAH	477
NON-CATEGORISED	432
FUJAIRAH	227
UMM AL QAIWAIN	108

4.2.11. Psychiatric Cases

The following table of psychiatric related case in the northern emirates was extracted from the National Ambulance database using Code 13 (Mental/Emotional/Psychological) in the *Patient Diagnosis* field of the patient care record (PCR) is included in Annexure H. The results are tabulated as totals by region for the study period. The role of $ECTO_2$ monitoring in patients with hyperventilation syndrome is significant[10]. The psychiatric cases highlighted in the table below (Table 13) are non-specific and the quantity of hyperventilation syndrome cases could not be isolated.

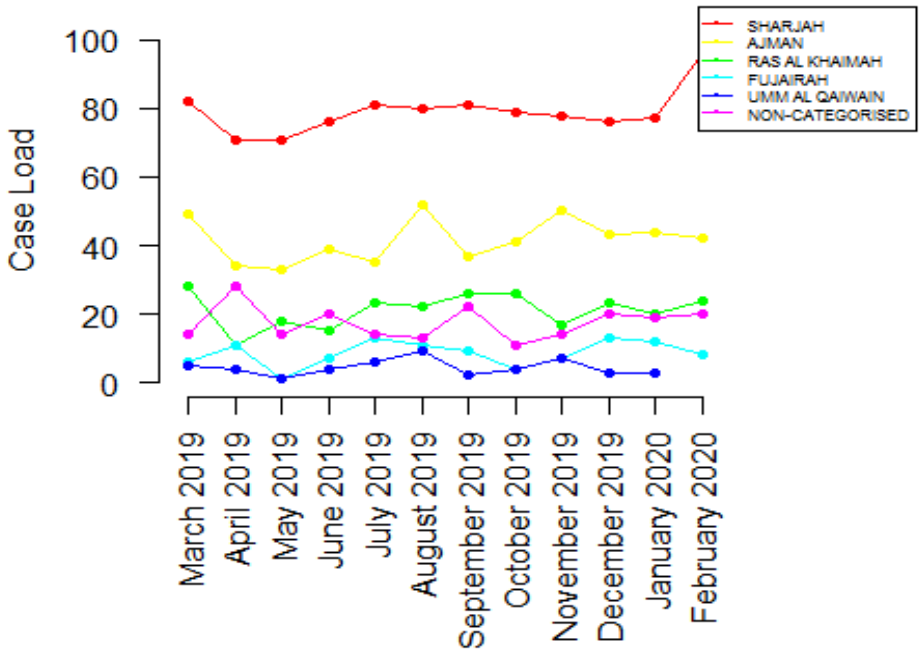
Table 13: Psychiatric regional caseload table from dataset

Emirate	Case Load
SHARJAH	948
AJMAN	499
RAS AL KHAIMAH	253
NON-CATEGORISED	209
FUJAIRAH	102
UMM AL QAIWAIN	48

The following table (Graph 5) of Psychiatric cases retrieved from the database for the study period provides the monthly totals by region; this information is then summarized in a line graph and is useful to highlight regional case load and opportunity for $ETCO_2$ monitoring. That being said the graph does not isolate patients with hyperventilation syndrome and therefore $ETCO_2$ monitoring may be applicable to only a portion of these cases but this quantity is unknown.

[10] Notwithstanding that some researchers argue that Hyperventilation Syndrome should not be categorized as a Psychiatric condition, capnography is still shown to be useful.

Graph 5: Psychiatric regional caseload graph with monthly trend.



4.2.12. Resuscitation Cases

The following was data retrieved from the database was filtered according to the '*Is Resuscitation Attempt*' variable from the patient care records. Resuscitation in these cases refers exclusively to Cardio-pulmonary Resuscitation (CPR) that were actively performed. The following are the regional totals for the study period (01 March 2019 to 29 February 2020) totalling 774 resuscitation events in the northern emirate area of study.

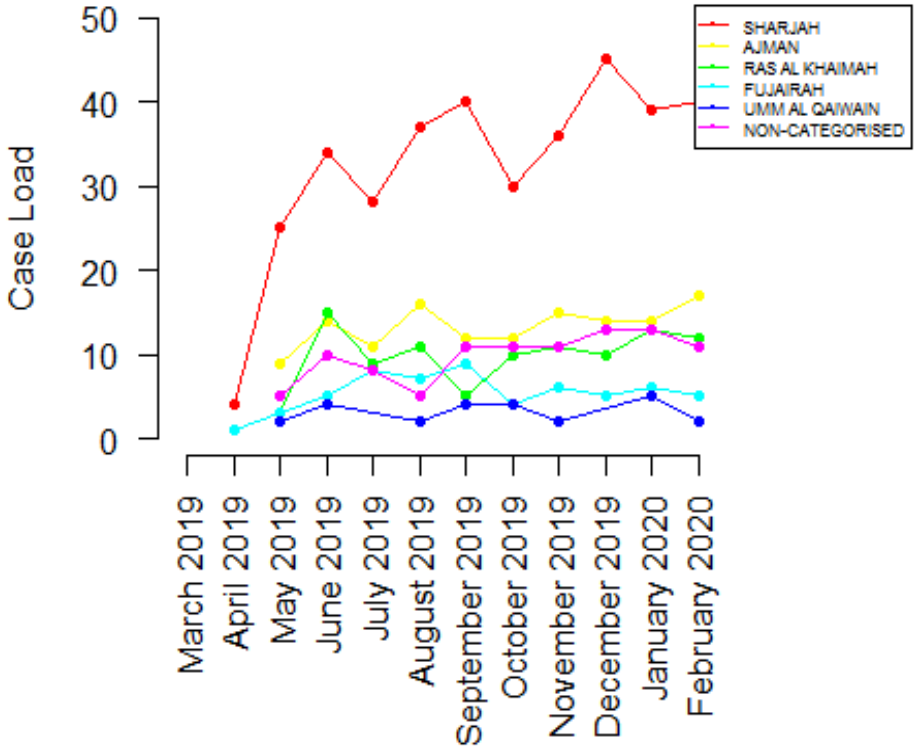
Table 14: Resuscitation regional caseload table from dataset.

Emirate	Case Load
SHARJAH	358
AJMAN	134
RAS AL KHAIMAH	100
NON-CATEGORISED	98
FUJAIRAH	59
UMM AL QAIWAIN	25

The following table (Graph 6) of CPR events in the northern emirates, gives the monthly totals by region. This information was then summarized into line graphs. This graph presents the

opportunities available for EMT-B staff to use capnography as a prognostic as well as a quality measure for patient care.

Graph 6: Resuscitation regional monthly caseload and trends.



4.2.13. Other Cases

Results thus far included Head Injuries, Respiratory pathology cases, Trauma cases, Psychiatric related cases and Resuscitation Cases. While these were case categories of interest, other cases that POCT $ETCO_2$ could potentially be used for include Allergic Reactions; Infectious Diseases - (inclusive of Covid-19 Cases); Diabetes; Environmental and Toxic Exposure cases, Overdose and Poisoning cases, Seizures, Stroke cases, Burns and Drowning Cases. These cases that may have effects on the airway or breathing are considered for $ETCO_2$ monitoring. To establish an "Other" category was created by sub-setting codes other than (05) Breathing Difficulty, (12) Head and Neck Injuries, 13 Mental, Emotional & Psychiatric Cases, and (21) Assault and Trauma cases. The following table of 'Other' case pathologies are the totals by region for the study period.

Table 15: Other cases for potential $ETCO_2$ use regional stratification table.

Emirate	Case Load
SHARJAH	12459
AJMAN	5845
RAS AL KHAIMAH	4299
NON-CATEGORISED	2894
FUJAIRAH	2390
UMM AL QAIWAIN	861

4.2.14. $ETCO_2$ Utilization

The table (Table 16) looks at the frequency of the overall usage statistics across all cases that were taken from the database with some potential of $ETCO_2$ monitoring. 'False' represents 'Not Used' when screened for usage. Any $ETCO_2$ values captured on the Patient Care Record (PCR) was considered as a 'True' value highlighting use of $ETCO_2$ monitoring. Frequency represents the number of patient events or cases. The relative frequency reflects the percentage value of use.

Table 16: $ETCO_2$ Utilization frequency table.

$ETCO_2$ Performed	Frequency	Relative Frequency
FALSE	37950	95.02
TRUE	1987	4.98

4.2.15. Utilisation by Pathology (Working Diagnosis)

The table of results below (Table 17) highlight the frequency of $ETCO_2$ Monitoring use according to the main pathologies with strong evidence of value associated with this type of POCT. The use of $ETCO_2$ monitoring in respiratory associated cases is significantly higher than the rest captured on the database. Cardio-Pulmonary Resuscitation (CPR) cases were included in the 'Other' category.

Table 17: $ETCO_2$ utilization per primary pathology cases identified for use table.

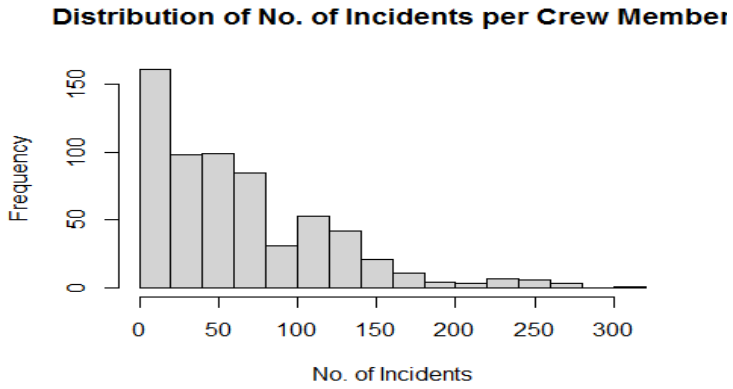
Patient Diagnosis Code	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
12 Head/Neck	1912	32	1.65
05 Breathing Difficulty	1942	482	19.88
21 Assault/Trauma	4632	130	2.73
13 Mental/Emotional/Psychological	2016	43	2.09
Other	27448	1300	4.52

A Pearson chi-square test of independence was conducted to check for an association between diagnosis and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between patient diagnosis code and $ETCO_2$ utilization (p-value: 6.51×10^{-277}).

4.2.16. Establishing the number of crew using $ETCO_2$ per region

The following histogram (Histogram 1) shows the distributions of the number of incidents attended per crew member, number of $ETCO_2$ performed per crew member, and the ratio of the two (number of Incidents per $ETCO_2$ Performed). Incidents for which, employee staff numbers were missing were omitted (these are mostly the resuscitation incidents, since 'Employee Number' were not part of that data set). For the record, employee staff numbers were recorded for the frequency estimation only and was not traceable to the individuals, at the research level access, afforded to the principal investigator. The graph highlights the number of EMT-B staff members frequency of exposure to potential cases for $ETCO_2$ monitoring. The detail of the derived results is reported in the discussion section of this document. The histogram shows that approximately 150 crew members were exposed more frequently to potential cases where $ETCO_2$ could be used than other 150 members of staff that had lesser opportunities.

Histogram 1: Distribution of $ETCO_2$ potential cases per crew member histogram.

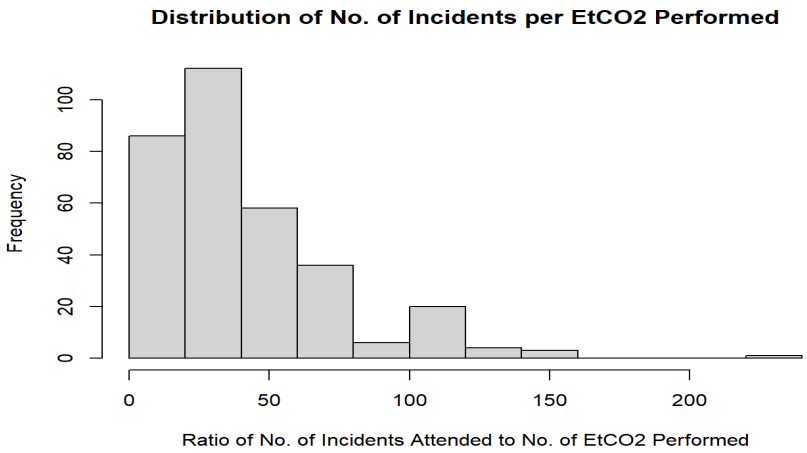


The table below represents the 'Frequency' of $ETCO_2$ monitoring events that were performed by EMT-B crew over the study period.

Table 18: Frequency Table of $ETCO_2$ use per crew member.

No. of $ETCO_2$ Performed	Frequency	Relative Frequency (%)
0	301	24.08
1	192	15.36
2	93	7.44
3-5	97	7.76
6-10	65	5.2
11-20	40	3.2
21-30	47	3.76
31-40	56	4.48
41-50	52	4.16
51-75	119	9.52
76-100	46	3.68
> 100	142	11.36

Histogram 2: Distribution of number incidents per $ETCO_2$ performed histogram.



The mean number of incidents attended per employee is 62.63 and the median is 50. The mean number of $ETCO_2$ performed per employee is 2.53 and the median is 1. The mean number of incidents attended per $ETCO_2$ performed is undetermined and the median is 113.

The following table (Table 19) shows frequency of employees who performed at least one $ETCO_2$ monitoring event. The relative frequency, shows the frequency in a percentage (%) form to highlight the number of staff that used $ETCO_2$ as a POCT. False represents 'Did not use' $ETCO_2$ at all during the study period while True denotes a 'Used/Practiced' $ETCO_2$ monitoring during the study period at least one (1) time. This table highlights capacity to perform POCT $ETCO_2$. The data shows that more than 50% the EMT-Bs in the cohort have conducted $ETCO_2$ monitoring and highlights the capability of the EMT-B's in practicing this function.

Table 19: $ETCO_2$ performed (min 1) relative to frequency it was performed table.

At Least 1 $ETCO_2$ Performed	Frequency	Relative Frequency
FALSE	299	47.84
TRUE	326	52.16

The following table (Table 20) shows frequency of employees who performed at least one $ETCO_2$, focusing only on employees who attended at least 30 incidents. This highlights that given the frequency of exposure staff will use POCT $ETCO_2$.

Table 20: $ETCO_2$ performed min. 1 per 30 incidents frequency table.

At Least 1 $ETCO_2$ Performed (30+)	Frequency	Relative Frequency
FALSE	121	28.67
TRUE	301	71.33

4.2.17. Regional $ETCO_2$ usage trends

The table (Table 21) is used to compare regional trends based on general $ETCO_2$ usage trends. The detail helps to identify which regions are more likely to use POCT $ETCO_2$ independent of frequency of exposure. Sharjah is associated with greater $ETCO_2$ usage trend than Umm-Al-Quwain with the least usage at 3.76%.

Table 21: $ETCO_2$ regional trends of $ETCO_2$ usage table

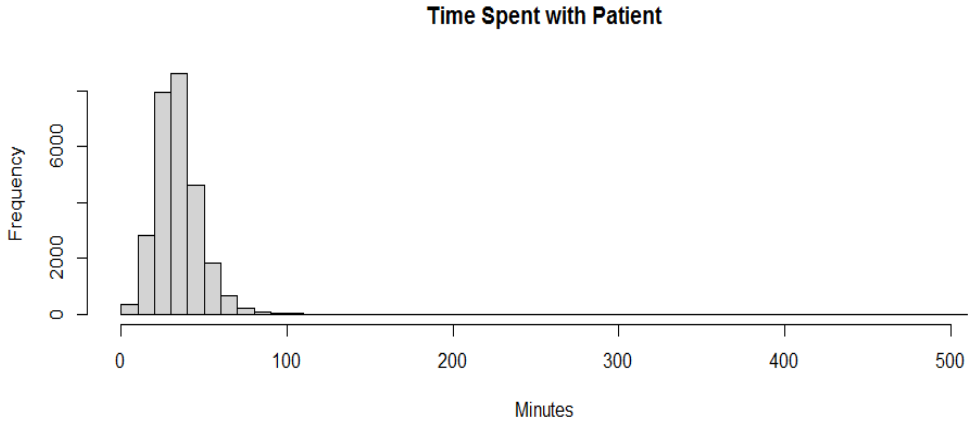
Emirate	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
SHARJAH	16645	1040	5.88
AJMAN	8131	364	4.28
RAS AL KHAIMAH	5415	204	3.63
NON-CATEGORISED	3840	189	4.69
FUJAIRAH	2844	148	4.95
UMM AL QAIWAIN	1075	42	3.76

A Pearson chi-square test of independence was conducted to check for an association between region and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between region and $ETCO_2$ utilization (p-value: 1.17×10^{-12}).

4.2.18. Establishment of Patient contact time with pathologies for $ETCO_2$ (Hist. 3).

The Histogram presented helps to highlight the opportunity of time available to medical crew for the possibility of POCT use. Time spent with patient was calculated by subtracting *'At Receiving Hospital Time'* minus *'At Patient Time'* from the patient care record (PCR) dataset. This measures the actual time that the medical crew has had contact with the patient from arriving at the patient's side to delivering the patient at hospital. There were some cases where the resulting time spent was negative or extremely large. (Cases where time spent was negative or more than 10 hours were assumed to have corrupted data and were ignored).

Histogram 3: Establishment of patient contact time with potential $ETCO_2$ use pathologies.



4.2.19. Patient contact time relative to POCT $ETCO_2$ usage.

The table (Table 22) presented below highlights the time interval that the medical crew spent with patients where POCT $ETCO_2$ was conducted vs. where POCT $ETCO_2$ was not conducted to identify whether contact time bears any relevance to $ETCO_2$ monitoring. Mean time spent with patient in minutes was 34.71 and median was 33.

Table 22: Patient contact time relative to POCT $ETCO_2$ use.

Mins Spent with Patient Interval	Freq without $ETCO_2$	Freq with $ETCO_2$	Relative Frequency $ETCO_2$
0 - 20	3102	115	3.57
20 - 30	7648	319	4.00
30 - 40	8183	443	5.14
40 - 50	4353	278	6.00
50 - 60	1711	124	6.76
> 60	1005	70	6.51

Mean time spent with patient (min) among non-$ETCO_2$ patients was 34.54 median was 33. Mean time spent with patient among $ETCO_2$ patients was 37.86; median was 36. A t-test was conducted to test the null hypothesis that mean time spent with patient is equal between both groups vs. the alternative that mean time spent with patient among $ETCO_2$ patients is greater than that among non-$ETCO_2$ patients. Null hypothesis was rejected with p-value of 1.5708042×10^{-9}; therefore, we conclude that mean time spent with patient was higher among $ETCO_2$ patients.

4.2.20. Establishment of $ETCO_2$ use trends in BLS CPR.

In this table (Table 23) BLS Resuscitation corresponds to cases where "*Is Resuscitation Attempt*" is "*Yes*" was taken from the Patient Care Records (PCR) and a Total of 774 active Cardio-Pulmonary Resuscitation (CPR) events were recorded. The table compares CPR cases to non-CPR cases and also differentiates between whether $ETCO_2$ was used or not. This information is useful to track actual usage of $ETCO_2$ in cases of the northern emirates. $ETCO_2$ monitoring was used 52.2% of the resuscitation cases. This shows relatively high utilization rates for this category of pathology.

Table 23: Establishment of $ETCO_2$ use trend with CPR

BLS Resuscitation	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
No	37580	1583	4.04
Yes	370	404	52.2

A Pearson chi-square test of independence was conducted to check for an association between BLS resuscitation (CPR only) and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between resuscitation and $ETCO_2$ utilization (p-value: 0).

4.2.21. $ETCO_2$ with CPR and Advanced Airways (incl. Supraglottic Airways SGA's).

Potential cases for $ETCO_2$ use were screened from the database. The data was judged to be SGA if the '*Pre Hosp Adv Airway*' variable had a value of "i-Gel® Airway" or "LMA" denoted. In the table False denotes 'Not Used' and True denotes 'Used' when tested for usage of SGAs with CPR cases from the dataset. This reflects that an SGA was placed by EMT-Bs in 692 cases of the total 774 CPR cases and 54.77% of the cases used $ETCO_2$ with the SGA and CPR. The high correlation of $ETCO_2$ use with SGAs in CPR Cases are significant findings for this study.

Table 24: CPR and SGA use in relation to POCT $ETCO_2$ application

CPR & SGA Used	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
FALSE	57	25	30.49
TRUE	313	379	54.77

A Pearson chi-square test of independence was conducted to check for an association between CPR & SGA utilization and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between CPR & SGA utilization and $ETCO_2$ utilization (p-value: 5.23×10^{-5}).

4.2.22. $ETCO_2$ use with LUCAS Compressor in CPR Cases

The American Heart Association (AHA) recommend $ETCO_2$ monitoring to observe and maintain good quality CPR during manual compressions. Due to single medical crew operations while the secondary crew is driving, National Ambulance opted to support the medical crew with a mechanical chest compressor manufactured by LUCAS®. The mechanical compressor is meant to provide good chest compressions consistently while also freeing up the EMT-B to do mechanical ventilation, secure a patent airway and provide some pharmacological intervention among other things. However, the LUCAS® compressor does get displaced with motion or the depth calibration may be incorrectly set. Therefore, capnography with mechanical chest compressions can monitor the quality of chest compressions to ensure good quality CPR. The table (Table 25) gives an indication of when $ETCO_2$ was used or not, in conjunction with the LUCAS Compressor during CPR events recorded on the database. The variable '*Mech CPR Device Used*' contained the term '*LUCAS*' was treated as a case where LUCAS compressor was used to extract data from the Patient

Care Records (PCRs). More than 50% $ETCO_2$ use with the external compressor device was observed.

Table 25: $ETCO_2$ use with LUCAS Compressor in CPR Cases

LUCAS Compressor Used	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
No	59	52	46.85
Yes	311	352	53.09

A Pearson chi-square test of independence was conducted to check for an association between LUCAS compressor utilization and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is not an association between LUCAS compressor utilization and $ETCO_2$ utilization (p-value: 0.264).

4.2.23. $ETCO_2$ use with CPR + ROSC

Good quality CPR maintained with the use of $ETCO_2$ monitoring has been shown to be associated with positive outcomes by the International Liaison Committee on Resuscitation (ILCOR) and is considered best practice. The table (Table 26) is used to demonstrate the number of events where there was Return of Spontaneous Circulation (ROSC) or no ROSC in the recorded resuscitation attempts in relation to capnography use, 62.04% ROSC was observed with $ETCO_2$ use.

Table 26: $ETCO_2$ use with CPR and ROSC table.

ROSC	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
No	323	334	50.84
Yes	41	67	62.04

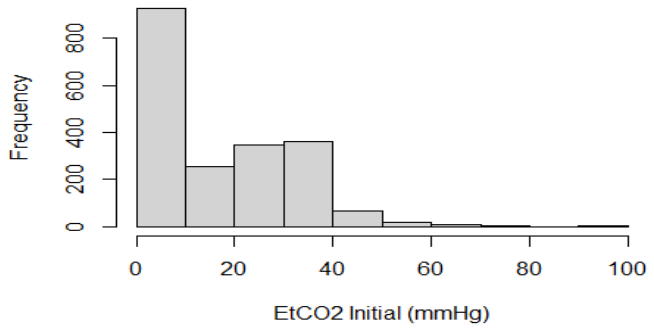
A Pearson chi-square test of independence was conducted to check for an association between ROSC occurrence and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between ROSC occurrence and $ETCO_2$ utilization (p-value: 0.0398).

4.2.24. $ETCO_2$ use < 10 mmHg $ETCO_2$ (initial) with CPR

In the histogram (Histogram 4) and table (Table 27) below relating to CPR and $ETCO_2$ monitoring, where the initial values recorded for the resuscitation attempt were less than 10 mmHg has been reported. The significance of these $ETCO_2$ values may be used as a prognostic value in resuscitation attempts (ILCOR). Using the '*Observe_Min_EtCO2'* recorded on the database, allowed the initial value of $ETCO_2$ in mmHg to be retrieved. The frequency of the low $ETCO_2$

reading is reported against the use of $ETCO_2$ use and this is also relevant, because the low $ETCO_2$ readings can also be used by the medical crew, as a prompt to increase the quality of chest compressions. The table also implicitly addresses events where there were $ETCO_2$ readings of greater than 10 mmHg associated with better quality of CPR and outcomes.

Histogram 4: Initial $ETCO_2$ records (mmHg) in dataset and frequency histogram.



Histogram of Initial $ETCO_2$ recordings (intervals of 10 mmHg) related to frequency

Table 27: $ETCO_2$ Value less than 10 mmHg relative to Frequency of Cases in Dataset

$ETCO_2$ Initial Value < 10	Frequency	Relative Frequency
FALSE	1076	54.15
TRUE	911	45.85

4.2.25. $ETCO_2$ use $\geq$ 20 mmhg $ETCO_2$ (initial) with CPR

The table (Table 28) below reflects the CPR events recorded on the database with $ETCO_2$ recording of equal to or higher that 20 mmHg. This highlights very good CPR quality or may be an indication of ROSC if associated with ,more than 25 mmHg showing increased prognosis.

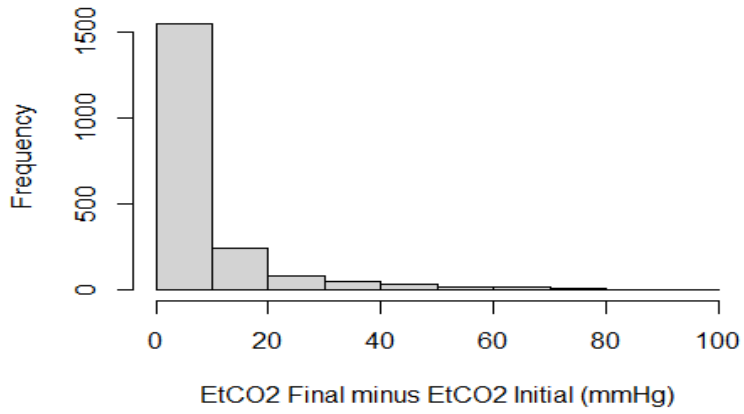
Table 28: $ETCO_2$ Value 20 mmHg relative to Frequency of Cases in Dataset

$ETCO_2$ Initial Value $\geq$ 20 mmhg	Frequency	Relative Frequency
FALSE	844	42.48
TRUE	1143	57.52

4.2.26. $ETCO_2$ use with Increasing $ETCO_2$ trends (with or without ROSC)

In histogram (Histogram 5) and table (Table 29) below, by using data variables observed '*Observe_Min_EtCO₂*' to retrieve the initial $EtCO_2$ value (mmHg) and the other '*Observe_Max_EtCO₂*' that gives the final $EtCO_2$ value (mmHg) and then subtracting the final minus initial value trend values were achieved. These values were then tabulated against ROSC, non-ROSC cases, and no-resuscitation cases. These trends are of particular interest because it can be used to reflect appropriateness of $ETCO_2$ use. The 0-10 mmHg category of $ETCO_2$ has the greatest escalation trend in more than 1500 cases where escalation in $ETCO_2$ were observed. Increasing $ETCO_2$ trends talks to increase quality of CPR. This highlights the correct application of $ETCO_2$ in resuscitation cases by the EMT-B cohort. The increasing $ETCO_2$ value trend in (Histogram 5) shows greater than 90% increase rates of $ETCO_2$ levels on patients that experienced ROSC.

Histogram 5: Histogram representing $ETCO_2$ use with increasing $ETCO_2$ value trends



Histogram of $ETCO_2$ use with Increasing $ETCO_2$ trends (with or without ROSC)

Table 29: $ETCO_2$ Increasing value trend in relation to ROSC table

ROSC	$ETCO_2$ Did Not Increase	$ETCO_2$ Increased	$ETCO_2$ Increased %
No	46	288	86.23
Yes	5	62	92.54
Non-Resuscitation Case	729	857	54.04

4.2.27. $ETCO_2$ use with post-resus monitoring

Post-resuscitation monitoring is assumed to have occurred in an ROSC case that has a non-NULL *Observe_Max_$ETCO_2$* value.

Table 30: $ETCO_2$ use with post resuscitation monitoring table.

$ETCO_2$ Performed	Frequency	Relative Frequency
FALSE	41	37.96
TRUE	67	62.04

4.2.28. Other Associations

Here is a table (Table 31) of frequency of non-$EtCO_2$ and $EtCO_2$ incidents by A/15 vs. all others. 'A' is part of a consciousness rating scale 'AVPU' where, the patients' response can quickly be rated. 'A' represents a rating of 'Alert', 'V' represents a response to 'Verbal stimulus', 'P' represents a response to 'Pain' and 'U' represents 'Unconsciousness'. Therefore, in this set of data, the rating of 'A' represents all patients that were recorded on the Patient Care Records (PCRs) as alert. The Glasgow Coma Scale (GCS) is also a rating scale to quantify a patients' level of consciousness on a rating of 15/15 as a full score. The score of 15 is the maximum score and implies that the patient was fully consciousness. The implication being that the patients in these cases filtered by the field 'A/15' were spontaneously breathing which, in-turn implies that they did not need the support of an artificial airway to where $ETCO_2$ adaptors may be attached. This analysis is of interest for the study because the data derived from this type of information, can indicate the use of $ETCO_2$ with spontaneous ventilation and $ETCO_2$ sampling of the fully conscious patients. Although, utilization of $ETCO_2$ monitoring of the conscious patient is low it highlights $ETCO_2$ use in this category of patients.

Table 31: $ETCO_2$ frequency of use / non-use with fully conscious patients.

Patient Status A/15	Freq without $ETCO_2$	Freq with $ETCO_2$	Relative Frequency $ETCO_2$
FALSE	4219	484	10.29
TRUE	32558	1099	3.27

4.2.29. $ETCO_2$ vs. Respiration Rate

The Histogram below (Histogram 6) and Table (Table 32) are particularly interesting for the purpose of the study. The relation between Respiratory Rate and $ETCO_2$ is observed in the latter. Variables, '*Observe Min RR*' as the indication of respiration rate for this analysis was retrieved from the patient care record database. The analysis includes both resuscitation and non-resuscitation cases. The Histogram (Histogram 6) highlights the frequency of the cases in relation to the Respiratory rates recorded on the Patient Care Records (PCRs). The table (Table 32) looks at the respiratory rate intervals in comparison to the $ETCO_2$ use or non-use. The information derived from this table highlights if $ETCO_2$ was used appropriately. The increased frequency of $ETCO_2$ use for decreased respiration and increased respirations beyond normal parameters (10-20 breaths per minute) highlights justified application of the POCT tool and also appropriate use.

Histogram 6: Respiratory rates intervals and frequency in dataset.

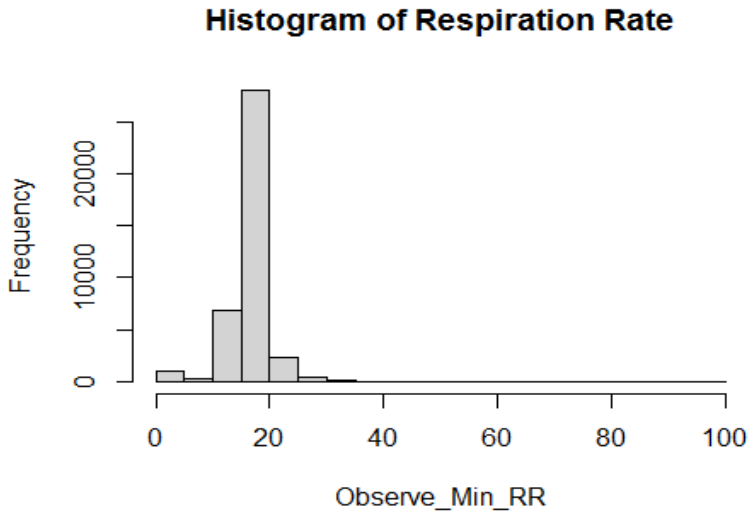


Table 32: Table of Respiratory Interval Rates vs. Frequency of $ETCO_2$ use recorded in dataset.

Respiration Rate Interval	Freq without $ETCO_2$	Freq with $ETCO_2$	Relative Frequency $ETCO_2$
0 - 5	498	437	46.74
5 - 10	229	71	23.67
10 - 15	6640	220	3.21
15 - 20	27176	858	3.06
20 - 25	2026	262	11.45
25 - 30	342	83	19.53
> 30	193	50	20.58

Mean respiration rate among non-$ETCO_2$ patients was 17.12; median was 17. Mean respiration rate among $ETCO_2$ patients was 14.77; median was 17. A t-test was conducted to test the null hypothesis that mean respiration rate is equal between both groups vs. the alternative that mean respiration rate among $ETCO_2$ patients is less than that among non-$ETCO_2$ patients. Null hypothesis was rejected with p-value of $4.5287735 \times 10^{-27}$; therefore, we conclude that mean respiration rate was lower, among $ETCO_2$ patients.

4.2.30. $ETCO_2$ use for Asthma cases in Dataset

Asthma is recognized as a respiratory pathology where $ETCO_2$ monitoring can inform the clinician of the patients' clinical condition and can also be used to monitor the patients' response to therapy. This table (Table 33) can also potentially highlight the appropriateness of use of $ETCO_2$ and is of interest of the study. the clinical condition was filtered from the database using '*Working Diagnosis*' variable. Incidents where the word 'Asthma' occurred in the field were considered Asthma cases. This includes explicit asthma attacks as well as incidents marked as possible asthma attacks or exacerbated by asthma. Since this variable does not occur in the resuscitation data, only non-resuscitation cases were considered in the dataset.

Table 33: Table of Asthma Cases and Frequency of $ETCO_2$ use in dataset

Asthma-Related	Frequency without $ETCO_2$	Frequency with $ETCO_2$	$ETCO_2$ Relative Frequency
FALSE	37452	1534	3.93
TRUE	128	49	27.68

4.2.31. $ETCO_2$ with BVM use analysis.

In medical care, supportive ventilation with adjunctive devices such as the use of Bag-Valve-Mask (BVM) devices are important interventions with patients that have compromised respiratory statuses. The table below (Table 34) highlights the BVM use relative to the resuscitation cases as well as to the frequency of $ETCO_2$ use. The variable used for analysis was the '*Chest BVM'* that was annotated as "Y" (Yes) in the dataset with values that were much more common in the Resuscitation data, hence analysis included non-resuscitation and resuscitation cases. The table (Table 34) also is an indication of appropriate use of $ETCO_2$.

Table 34: Table of BVM in Resuscitation and Non-Resuscitation Cases vs $ETCO_2$ use

BVM & Resus Combination	Frequency without $ETCO_2$	Frequency with $ETCO_2$	$ETCO_2$ Relative Frequency
BVM, Non-Resus	116	113	49.34
BVM, Resus	264	310	54.01
No BVM, Non-Resus	37464	1470	3.78
No BVM, Resus	106	94	47.00

4.2.32. $ETCO_2$ vs. Shock Index

The use of $ETCO_2$ in Shock has been highlighted in research although there are mixed opinions on the appropriateness of $ETCO_2$ use in these cases. National Ambulance has an inbuilt formula on the tool used to collect electronic Patient Care Records (PCRs). The tool automatically calculates the Shock Index (SI) when the patient related data are inputted to the device. If a value greater than 0.9 is observed, the patient is considered to be in a state of shock. The Variable used for analysis was the '*Observe Min Shock Index' from the PCR database*. The SI has been a reliable indication of Shock and warns the medical crew of the patient disposition when a score indicating that the patient data signals signs of shock. Therefore, $ETCO_2$ monitoring of these cases may have not be necessary. However, out of interest the $ETCO_2$ in relation to the SI data were analyzed. Histogram 7, highlights the SI intervals from the dataset. $ETCO_2$ monitoring has been used in just over 5% on patients with some degree of shock.

Histogram 7: Minimum Shock Index vs. Frequency of Cases (Shock) in database.

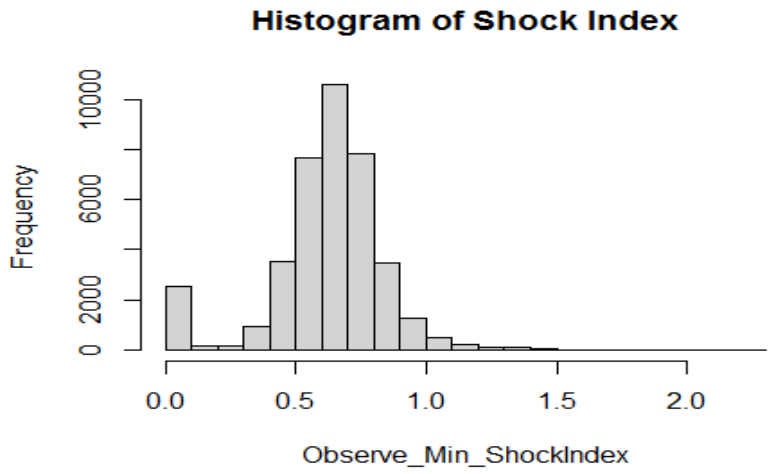


Table 35: Shock Index (SI) vs. Frequency of $ETCO_2$ use and non-use

Shock Index Interval	Freq without $ETCO_2$	Freq with $ETCO_2$	Relative Frequency $ETCO_2$
0 Exactly	1828	619	25.30
> 0 - 0.5	4626	229	4.72
0.5 - 0.75	22107	761	3.33
0.75 - 1	7708	325	4.05
> 1	913	53	5.49

Mean shock index among non-$ETCO_2$ patients was 0.63; median was 0.65. Mean shock index among $ETCO_2$ patients was 0.46; median was 0.56. A t-test was conducted to test the null hypothesis that mean shock index is equal between both groups vs. the alternative that mean shock index among $ETCO_2$ patients is less than that among non-$ETCO_2$ patients. Null hypothesis was rejected with p-value of $2.1115793 \times 10^{-98}$; therefore, we conclude that mean shock index as lower among $ETCO_2$ patients. There may be confounding factors for this result that is elaborated in the discussion.

4.2.33. Gender vs. $ETCO_2$ (for bias detection)

In the United Arab Emirates (UAE) there is a large expatriate workforce contingent which are predominantly male (Global Media Insight, 2020). In Arab countries the Islamic Law prevails, and although the large expatriate community allows for a liberal lifestyle in the urban centers, the orthodox less commercialized areas of the northern emirates sometimes are more rigid in terms of the Islamic culture. In some instance male care givers may not be able to assess or treat a

female patient in an emergency, due to males not being permitted to touch (non-familial) females according to Islamic culture. Therefore, the table below (Table 36) may be used to highlight the use of $ETCO_2$ across the gender line to determine if there is any difference in the use of $ETCO_2$. Conversely, using $ETCO_2$ may be an alternative to having to physically assess female patients using a stethoscope or exposing the patient to observe ventilations in the UAE setting. It must be noted in the dataset that Gender was unspecified in 903 cases and these were excluded from the analysis below.

Table 36 – Relates to Gender vs $ETCO_2$ use and non-use in dataset.

Patient Gender	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
F	12675	662	4.96
M	24413	1284	5

A Pearson chi-square test of independence was conducted to check for an association between gender and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is not an association between gender and $ETCO_2$ utilization (p-value: 0.906).

4.2.34. Emirate vs. $ETCO_2$ (for bias detection).

Table 37 below is used to differentiate the use/non-use of $ETCO_2$ among the Emirates of UAE. This will help to identify the consistencies or non-consistencies of $ETCO_2$ use.

Table 37: Emirates of UAE comparisons of $ETCO_2$ use and non-use.

Emirate	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
AJMAN	8131	364	4.28
FUJAIRAH	2844	148	4.95
NON-CATEGORISED	3840	189	4.69
RAS AL KHAIMAH	5415	204	3.63
SHARJAH	16645	1040	5.88
UMM AL QUWAIN	1075	42	3.76

A Pearson chi-square test of independence was conducted to check for an association between Emirate and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between Emirate and $ETCO_2$ utilization (p-value: 1.17×10^{-12}). Specifically, $ETCO_2$ use appears to be highest in Sharjah Emirate and lower in the Emirates of Ras Al Khaimah and Umm Al Quwain.

4.2.35. Age vs. $ETCO_2$ (for bias detection)

The histogram (Histogram 8) below is used to highlight the demographic age distribution according to frequency appearing in the dataset. It was noted that the age was unspecified in 658 cases in the dataset and these were excluded from the analysis. The histogram serves as a baseline representation of age distribution of the cases, and can lend perspective to (Table 38) the age distribution compared to $ETCO_2$ use/non-use. The relevance of the information is to determine any bias of use in terms of the patient age distribution.

Histogram 8: Age distribution of cases relative to frequency in dataset

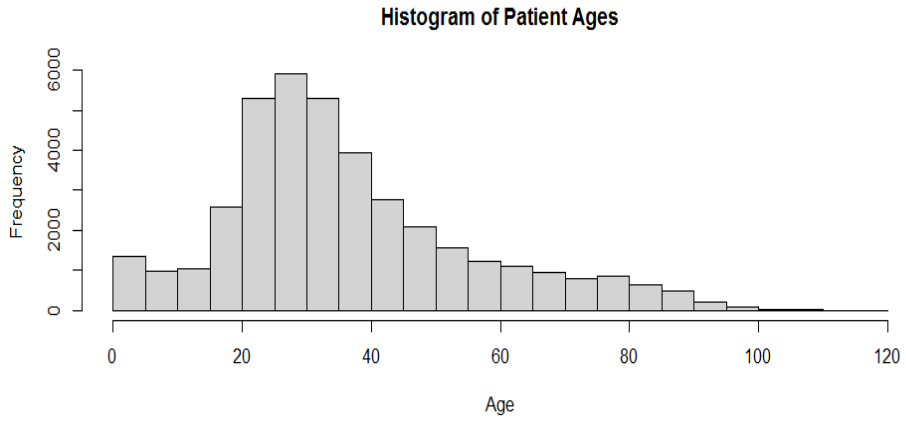


Table 38: Patient age distribution in relation to $ETCO_2$ use and non-use.

Patient Age	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
0 - 15	3230	137	4.07
15 - 30	13316	463	3.36
30 - 45	11511	511	4.25
45 - 60	4538	336	6.89
60 - 75	2572	277	9.72
> 75	2156	232	9.72

The mean age across all patients was 36.94 and median was 33. Mean age among non-$ETCO_2$ patients was 36.54; median was 32. Mean age among $ETCO_2$ patients was 44.65; median was 41. A t-test was conducted to test the null hypothesis that mean age is equal between both groups vs. the alternative that mean age among $ETCO_2$ patients is greater than that among non-$ETCO_2$ patients. Null hypothesis was rejected with p-value of $1.9123169 \times 10^{-52}$; thus, we conclude that mean age is greater among patients receiving $ETCO_2$ than patients not receiving $ETCO_2$.

4.3 Phase 3 – Survey Results: Descriptive Analysis

The intention was to include the entire population of 439 EMT-B staff in the survey. However, due to some pragmatic reasons (e.g., staff on sick or vacation leave during the survey period, and the limited window during which the online survey could be kept open and follow-ups made), as well as the voluntary nature of participation, the total number of responses received was 281 of 382 available staff at the time of Survey; a response rate of 74.56%. This was considered a reasonably good response rate under the circumstances.

4.3.1. Response to Survey Question: Have you received any exposure to education on $ETCO_2$ / Capnography?

Table 39: EMT-Bs education exposure to $ETCO_2$ and/or capnography.

Category	Frequency	Relative Frequency
Yes	221	81%
No	52	19%

The perception of the EMT-Bs in the cohort reflect, that the vast majority (81%) of the respondents have received $ETCO_2$ education. These results are concurrent with National Ambulance education programmes, that provide training. The Basic Airway Course, Pre-Hospital Trauma Life Support (PHTLS) Course, Advanced Cardiac Life Support (ACLS) Course and Pediatric Advanced Life Support (PALS) Courses all offer some degree of information on $ETCO_2$/Capnography to the EMT-Bs. Notably, not all EMT-Bs would be able to access the ACLS and PALS Courses, and it would be considered beyond their scope of practice as EMT-Bs. However, due to EMT-Bs Nursing degree background (Table 69), and privileging in extended scope practice (Ayman, 2019), they may be afforded access to the ACLS and PALS courses. Of particular significance, is that the majority of the EMT-Bs have some exposure to $ETCO_2$/Capnography.

4.3.2. Response to survey question: Can capnography ($ETCO_2$) be used for each of the following?

4.3.2.1. As an indicator of Supra Glottic Airway (SGA) (i-Gel®) tube placement confirmation?

Table 40: Results on EMT-Bs perception of $ETCO_2$ possible use for SGA tube placement confirmation.

Category	Frequency	Relative Frequency
Definitely	147	57.4%
Possibly	55	21.5%
Not Normally	27	10.5%
Never	15	5.9%
Don't Know	12	4.7%

The results attained from the survey highlighting that 57.4% of the cohort, believes that $ETCO_2$/Capnography can definitely be used as a POCT, for the assessment of placement of the SGA, together with 21.5% of the cohort deeming the capnography use is a possibility for the same purpose, constitutes the majority of 78.9%. SGAs like the branded i-Gel® is commonly used at National Ambulance in the northern emirates, and falls within the EMT-Bs scope of practice.

4.3.2 2. As a tool to guide patient ventilation using a Bag-Valve Mask (BVM)

Table 41: Results on EMT-Bs perception of $ETCO_2$ possible use for BVM guided ventilation.

Category	Frequency	Relative Frequency
Definitely	181	71.3%
Possibly	56	22%
Not Normally	8	3.1%
Never	4	1.6%
Don't Know	5	2%

The results of the survey indicate, that majority of the cohort, is of the opinion that definitely (71.3%), and with possibility (22%) that, $ETCO_2$/capnography can be used to guide ventilation, using a Bag-Valve Mask (BVM). In busy scenarios or multi-tasking, where there may be diluted

attention to the task of support ventilation, the overzealous clinician in ventilation attempts in patients are well documented (Wiesmann, 2008; Bucher, *et al.*, 2021). The adverse, out-of-hospital setting with high noise levels, exacerbate difficulties in assessing or monitoring patient ventilation attempts. POCT tools like capnography, have been advocated as control measures, to guide required ventilation support, based on objective values and parameters in patient care (Bucher and Cooper, 2018). Therefore, capnography as an objective measure in the diagnostics or supportive management of BVM ventilations, can be of great value. EMT-Bs in the northern emirates by majority seem to acknowledge that capnography use with BVM Ventilation has value, while the minority (6.7%) are not of the same opinion.

4.3.2.3. To manage ventilation in Traumatic Brain Injury (TBI) patients?

Table 42: Results: EMT-Bs perception of $ETCO_2$ use in managing Ventilation of TBI Patients.

Category	Frequency	Relative Frequency
Definitely	163	63.7%
Possibly	77	30.1%
Not Normally	8	3.1%
Never	3	1.2%
Don't Know	5	2%

The perception of the EMT-Bs, that $ETCO_2$/Capnography can be used to manage traumatic Brain Injury Patients (TBIs), are in the majority. Hypoxia in Head Injury patients, with TBI has been shown to increase morbidity and mortality if not corrected. The majority of the EMT-Bs acknowledge the value of $ETCO_2$/Capnography in dealing with TBI patients.

4.3.2.4. To monitor the quality of cardio pulmonary resuscitation (CPR)?

Table 43: Results of EMT-Bs perception of $ETCO_2$ possible use in CPR.

Category	Frequency	Relative Frequency
Definitely	221	86.3%
Possibly	28	10.9%
Not Normally	3	1.2%
Never	3	1.2%
Don't Know	1	0.4%

The results of the question relating to capnography/$ETCO_2$ use, for monitoring quality of CPR, was overwhelmingly in favor of its use, with 86.3% of the respondents answering 'Definitely' yes. The fact that the EMT-Bs in the cohort, confidently agree, that capnography does have a role in monitoring CPR Quality in a resuscitation attempt (Kodali, 2013), highlights that they have exposure to this knowledge.

4.3.2.5. To predict the outcome for a patient that is being resuscitated in cardio-pulmonary arrest?

Table 44: Results on EMT-Bs perception of $ETCO_2$ possible use as a predictor of CPR Outcomes.

Category	Frequency	Relative Frequency
Definitely	182	71.4%
Possibly	59	23.1%
Not Normally	6	2.4%
Never	5	2%
Don't Know	3	1.2%

4.3.2.6. To monitor a patient that is spontaneously breathing and fully alert (GCS 15/15)

Table 45: Results of EMT-Bs perception of $ETCO_2$ possible use, for monitoring fully alert spontaneous breathing patients.

Category	Frequency	Relative Frequency
Definitely	113	44.1%
Possibly	55	21.5%
Not Normally	65	25.4%
Never	21	8.2%
Don't Know	2	0.8%

Only 44% of the respondents selected the option that $ETCO_2$ can definitely, be used for fully alert (GCS 15/15) spontaneously breathing patients. A further 21.5% supported the possibility of its ($ETCO_2$) use, in the selected patient category.

4.3.2.7. To determine risk of deterioration in Covid-19 patients

Table 46: Results of EMT-Bs perception of $ETCO_2$ possible use for determining risk of deterioration in Covid-19 (Infectious Patients).

Category	Frequency	Relative Frequency
Definitely	130	50.8%
Possibly	95	37.1%
Not Normally	13	5.1%
Never	7	2.7%
Don't Know	11	4.3%

The study period of the historical data, (Phase 2) ranged from 01 March 2019 to 28 February 2020 which, was the pre-Covid-19 era in the middle east. Therefore, capnography utilization trends result, may not reflect current pandemic findings. However, the survey conducted late in December 2020, after the 1st wave of the pandemic, may have sensitized clinicians generally, to ventilation pathology associated with Covid-19. For the purposes of the study, it is also worthy of note, that Covid-19 potential or confirmed cases, were classified under the category of 'Infectious Patients.' Therefore, isolation of the Covid-19 case load alone, was difficult to determine.

4.3.3. Diagnostic scenario question on CPR and Capnography

Figure 7: Capnograph and Capnometry Illustration

The response to a scenario question on diagnostics of Cardio-pulmonary Resuscitation (CPR) being performed on a patient that collapsed. Given the $ETCO_2$ reading displayed on the monitor of 18 mmHg, what does it imply about the quality CPR being performed?

Table 47: Results of EMT-Bs perception on the diagnostic value of 18 mmHg $ETCO_2$ in a scenario where CPR is being performed.

Category	Frequency	Relative Frequency
Inadequate CPR is being performed	117	45.7%
Adequate CPR is being performed	102	39.8%
None of the above apply to the Capnography trace shown above.	14	5.5%
Unsure	12	4.7%
This is an indication of Return of Spontaneous Circulation (ROSC)	11	4.3%

The survey questions on capnography and $ETCO_2$, was intended to evaluate the diagnostic ability of the EMT-Bs, given realistic values that would be obtained in the field. The scenario question on an $ETCO_2$ value of 18 mmHg, being obtained while conducting CPR on a patient relates to the quality of CPR being performed.

4.3.4. Diagnostic scenario question on Capnography and ROSC

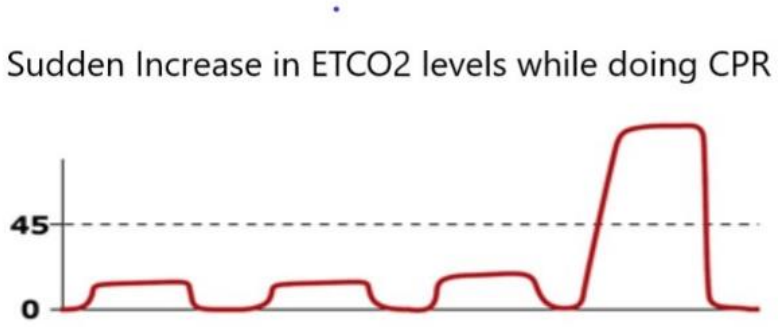


Figure 8: Capnography Illustration with sudden escalation in $ETCO_2$ Value.

The following is a response to a scenario question related to diagnostics in resuscitation posed as: After approximately 2 minutes of CPR, you notice a sudden change in the graph presented on your monitor with $ETCO_2$ (+ 45 mmHg) What can you conclude from the capnography graph presented above?

Table 48: Results of EMT-Bs perception on the diagnostic value of the sudden escalation in $ETCO_2$ (+45 mmHg) in a scenario where CPR is being performed.

Category	Frequency	Relative Frequency
This is an indication of Return of Spontaneous Circulation (ROSC)	171	66.8%
Adequate CPR is being performed	51	19.9%
Unsure	18	7%
Inadequate CPR is being performed	8	3.1%
None of the above apply to the capnography trace shown above	4	1.6%
This is a Normal Capnography Trace	4	1.6%

The CPR case scenario, reviews the diagnostic interpretation of a capnograph waveform, that may be realistically encountered, in a resuscitation attempt. In such an event the capnography may be an indicator of the Return of Spontaneous Circulation (ROSC) and the particular scenario presented (Sandroni, De Santis and D'Arrigo, 2018), tests the use and understanding of the capnography by the EMT-Bs where ROSC is achieved.

CPR is attempted, in the event that there is a chance, that the patient may be resuscitated. In the pre-hospital setting, the detection of a palpable pulse (when no CPR is being performed at the time), is an indication that the patient's heart has started contracting (beating) on its own again. However, trying to detect ROSC is not always easy and may be subject to many variables.

4.3.5. Diagnostic scenario question on Capnography and Traumatic Brain Injury (TBI)

Figure 9: Capnograph Illustration with low frequency respiration rate.

The response results to a scenario question related to diagnostics posed as: You are assisting ventilation in a patient that has a traumatic brain injury (TBI). The $ETCO_2$ value has escalated to above 45 mmHg and the Respiratory Rate (RR) was 6/min. The patient started (Decerebrate) posturing. At BLS level is there anything you can do (based on the graph presentation) in an attempt to assist this patient from deteriorating as the next step?

Table 49: Results of EMT-Bs perception on the diagnostic value of the $ETCO_2$ (+45 mmHg) capnography in guiding the next step of treatment of a TBI patient with hypoventilation.

Category	Frequency	Relative Frequency
Increase Ventilation Rate with a BVM next	157	61.3%
Rapid Transport to hospital next	34	13.3%
Decrease the ventilation rate with a BVM next	30	11.7%
Get ready to do CPR next	16	6.2%
Unsure	15	5.9%
Insert an IV Line next	4	1.6%

4.3.6. Diagnostic scenario question on capnography and bronchoconstriction.

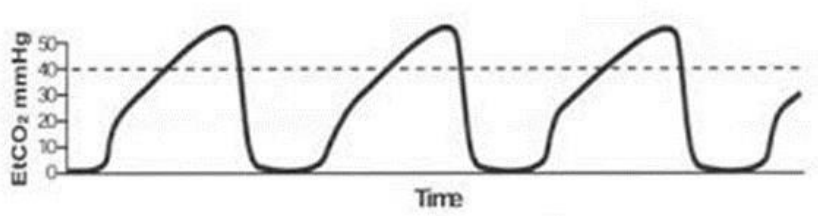


Figure 10: Capnography Illustration with "Shark Fin Waveform."

Response results to a scenario question relating to diagnostics posed as: In a patient that is experiencing difficulty in breathing, the following capnograph(above) is monitored with a respiratory rate of 20 breaths per minute What Clue does this graph give you about the patient with difficulty in breathing?

Table 50: Results of EMT-Bs perception on the diagnostic value of the $ETCO_2$ capnography 'Shark-fin' waveform associated with a patient experiencing difficulty in breathing.

Category	Frequency	Relative Frequency
The patient may have Bronchospasm	113	44.1%
The patient is hyperventilating	104	40.6%
Unsure	21	8.2%
This is a normal capnograph / $ETCO_2$ Waveform	17	6.6%
The patient is Choking	1	0.4%

4.3.7. Response to survey question: Were you ever exposed to any capnography ($ETCO_2$) training / education in your 'Extended Scope' or other training courses at National Ambulance?

Table 51: EMT-Bs perception on exposure to training/education of Capnography ($ETCO_2$) at National Ambulance.

Category	Frequency	Relative Frequency
Yes	150	59.1%
No	71	28%
Maybe	33	13%

From the results of the survey question on the EMT-Bs perception of exposure to training /education of capnography, the majority by 59.1%, do admit exposure. The degree of training and education is further delved into in section 4.3.26. Response to survey question: On which category of training was there $ETCO_2$ exposure. However, it must be noted at this stage that exposure may be intentionally vague, as a formal programme for the use of capnography as a POCT tool is yet to be established at National Ambulance. Although, there are many courses, that contain elements of capnography in their composition, and may have afforded respondents some degree of exposure at EMT-B level of care.

4.3.8. Response to survey question: Have you come across any formal document (policy/protocol/guidelines) at National Ambulance that encourages the use of capnography analysis in patient care?

Table 52: EMT-Bs perception of formal documents (Policy, Protocol, Guideline) at National Ambulance that encourages use of capnography in patient care.

Category	Frequency	Relative Frequency
Yes	172	67.7%
Maybe	50	19.7%
No	31	12.2%
Other (please specify)	1	0.4%

4.3.9. Response to survey question: In your opinion can capnography inclusion at BLS level, help you to deal with some patient conditions you are exposed to?

Table 53: EMT-Bs perception of capnography inclusion into scope contributing to value in helping to deal with patient conditions that they are exposed to.

Category	Frequency	Relative Frequency
Certainly	188	74%
Probably	60	23.6%
Unsure	6	2.4%
Probably Not	0	0%
Certainly Not	0	0%

Majority (74%) of the respondents, believe with certainty, that capnography at BLS level will help deal with some of the patient conditions that they are exposed to. With caution of bias, this is an encouraging result highlighting the perceived value of capnography at EMT-B level.

4.3.10. Response to survey question: How useful has the Capnography ($ETCO_2$) Education & Training exposure that you received thus far been in helping you to use capnography analysis as a diagnostic/POCT tool?

Table 54: EMT-Bs perception of value of $ETCO_2$ Education and Training received thus far in contribution to capnography being used as a diagnostic tool.

Category	Frequency	Relative Frequency
Extremely useful	63	24.8%
Very useful	126	49.6%
Moderately useful	35	13.8%
Slightly useful	14	5.5%
Completely useless	9	3.5%
Not Applicable	7	2.8%

4.3.11. Response to survey question: How adequate are the Patient Care Protocol (CPG 134) guidelines for the use of capnography ($ETCO_2$)? (Protocol refers to the National Ambulance approved guidelines that is used as a reference for recommended patient care in the field).

Table 55: Perception of the EMT-Bs on the adequacy of the Patient Care Protocols (CPG134) guidelines for the use of capnography ($ETCO_2$).

Category	Frequency	Relative Frequency
Mostly Adequate	126	49.6%
Completely Adequate	55	21.7%
Unsure	53	20.9%
Mostly Inadequate	16	6.3%
Completely Inadequate	4	1.6%

4.3.12. Response to survey question: How easy is capnography ($ETCO_2$) monitoring to set-up and use? (This refers to the ability to configure the $ETCO_2$ to facilitate sampling of expired CO_2 in patient care)

Table 56: Perception of the EMT-Bs capnography ($ETCO_2$) monitoring set-up and ease of use.

Category	Frequency	Relative Frequency
Always easy	126	49.8%
Usually easy	110	43.5%
Sometimes easy	13	5.1%
Never easy	3	1.2%
Not Applicable/ Don't know	1	0.4%

4.3.13. Response to survey question: How often, in your current workplace setting, are the tools required to conduct capnography ($ETCO_2$) available (e.g., Life Pak 15 Monitor, $ETCO_2$ Nasal sampling tubes, $ETCO_2$ adaptors etc.)?
(Monitor in this context refers to the multi-purpose ECG machines used in EMS, that is capable of graphical representation of patient electro-cardiograms (ECG), oxygen saturations, capnography and $ETCO_2$, blood pressure recordings etc.)

Table 57: Perception of EMT-Bs on the tools, availability for the use of capnography in the current workplace setting.

Category	Frequency	Relative Frequency
Always	85	33.6%
Usually,	96	37.9%
Occasionally	69	27.3%
Never	2	0.8%
Not Applicable (never used capnography - $ETCO_2$) / Unsure	1	0.4%

4.3.14. Response to survey question: Do you receive any Clinical Audit feedback on Capnography $ETCO_2$ use for patient care at any stage?

{Feedback, in this context refers to responses in terms of (enquiry, advice or concern) received from the clinical governance teams dealing with clinical audit on patient care in the field and/or annotated on the patient care records}.

Table 58: EMT-Bs perception on the receipt of clinical audit feedback of Capnography / $ETCO_2$ use for patient care.

Category	Frequency	Relative Frequency
Always	2	0.8%
Usually	26	10.3%
Occasionally	68	26.9%
Never	134	53%
Not Applicable	23	9.1%

4.3.15. Response to survey question: How often do you observe triggers that remind you to use $ETCO_2$ monitoring in cases where there may be value?

Table 59: on EMT-Bs perception on triggers that may remind them to use $ETCO_2$ monitoring on cases where they may be value.

Category	Frequency	Relative Frequency
Always	67	26.5%
Usually	97	38.3%
Occasionally	84	33.2%
Never	4	1.6%
Not Applicable	1	0.4%

Triggers that may remind the EMT-Bs to use capnography, may be in the form of protocols and guidelines, but can also be like prompts on the Patient Care Records (PCR) documents, that clinicians are compelled to complete during the course of their patient management routine, as an official and legal record. The respondents in the survey highlight that about 26.5% 'always' observe triggers and 38.35% 'Occasionally' observe triggers, that remind them to use capnography, where there might be of value. A remaining third of the respondents (33,2%), indicate that triggers are occasionally encountered.

4.3.16. Response to survey question: How much pressure do you feel from your superiors to use capnography ($ETCO_2$)?

Whilst the majority of respondents (n = 213) reported little to no pressure to use $ETCO_2$, 14. 6% (n = 37) perceived significant pressure and 3 (n) respondents reported "a lot of pressure" (Table 60).

Table 60: Perception of EMT-Bs on the pressure felt from superiors to use capnography ($ETCO_2$).

Category	Frequency	Relative Frequency
A lot of pressure	3	1.2%
Significant pressure	37	14.6%
Little pressure	107	42.3%
No Pressure	106	41.9%

4.3.17: Response to survey question: Have you ever been in a situation where you connected up the $ETCO_2$ sampling line to the monitor and got a value of $ETCO_2$ but did not use the information further to direct treatment?

One hundred and three (n, 40.7%) respondents had always derived value from the $ETCO_2$ in terms of directing treatment (Table 61). The table suggests more utility than futility of sampling and monitoring $ETCO_2$.

Table 61: Perception of EMT-Bs on situations where there was $ETCO_2$ sampling without use in further directing patient treatment.

Category	Frequency	Relative Frequency
Always	1	0.4%
Often	19	7.5%
Occasionally	73	28.9%
Never	103	40.7%
Cannot remember	57	22.5%

4.3.18: Response to survey question: Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?

Table 62 suggests that most respondents were adequately trained to cope with capnography. A minority (12.6%) are in need of further training and support.

Table 62: EMT-Bs perception of adequacy of training in coping with the capnography ($ETCO_2$) technology at EMT-B scope of practice.

Category	Frequency	Relative Frequency
Definitely I can cope easily (No further training/support required)	7	2.8%
Yes, I can cope (adequately)	100	39.5%
Most times I can cope (further training and support will help)	113	44.7%
Not really (I need further training and support)	32	12.6%
Not at all for BLS level of care (too much for me)	1	0.4%

4.3.19. Response to survey question: Have you perceived any $ETCO_2$ recordings to be unreliable/ inaccurate during patient care?

'Never' suggests that 47.8% (n, 121) respondents did not question the $ETCO_2$ values received in any of their experiences. This implies confidence in the testing system and process providing accurate results. conversely, 'Usually' refers to the frequency of results being unreliable or inaccurate and shows a lack of trust. This in turn may create doubt, and 5.5% (n, 14) respondents fall into this category. The 'Occasional' group of respondents 43.5% (n, 110) refers to those respondents that questioned the results or values of $ETCO_2$ received sometimes but not frequently and have implications on viewing the results in context of other patient observations.

Table 63: EMT-Bs perception on the $ETCO_2$ recordings on un-reliability/ inaccuracy during patient care.

Category	Frequency	Relative Frequency
Always	3	1.2%
Usually,	14	5.5%
Occasionally	110	43.5%
Never	121	47.8%
Not Applicable	5	2%

4.3.20. Response to Demographic information request on respondents: Age Group.

Category	Frequency	Relative Frequency
<= 25	5	1.9%
26-30	92	34.8%
31-35	139	52.7%
36-40	25	9.5%
> 40	3	1.1%

Demographic details retrieved from the survey, highlight that the group of EMT-Bs in the northern emirates, are between the ages of 26-35 years old by majority. This highlights the well experienced and mature group of EMT-Bs with most of them having between 4-10 years of experience (Table 66 – Table on experience levels of respondents). Therefore, implementation

of capnography with this group may be more achievable and a safer option to deal with new technologies, given their experience levels and maturity.

4.3.21. Response to Demographic information on respondents: Gender

Table 64: EMT-Bs age groups at (Northern Emirates) National Ambulance at the time of survey. (Table Deleted)

Category	Frequency	Relative Frequency
<= 25	5	1.9%
26-30	92	34.8%
31-35	139	52.7%
36-40	25	9.5%
> 40	3	1.1%

The age group table highlights that majority of the EMT-Bs that participated in the survey were in the 31- to 35-year-old grouping, thus representing a mature group.

Table 65: The gender distribution of EMT-Bs at National Ambulance at the time of survey.

Category	Frequency	Relative Frequency
Male	198	73.6%
Female	71	26.4%

In a once dominated male profession, it is refreshing to note the gradual increase in female EMTs that are joining the profession. Just over 25% of the EMT-respondents were female, and although gender differences implications in the study may have little relevance at this stage, the gender equality is an important issue in the EMS fraternity. In the UAE setting there is a need for more female EMTs to deal with female patients, to preserve dignity and respect values, aligned with the Shariah Law of the country.

4.3.22. Response to demographic information on respondents: Years of Experience as EMT-B.

Table 66: The EMT-Bs years of experience as EMT-Bs at the time of survey.

Category	Frequency	Relative Frequency
Less than 2 years	7	2.6%
2 - 4 years	31	11.3%
4 - 6 years	114	41.6%
6 - 8 years	0	0%
8 - 10 years	99	36.1%
More than 10 years	23	8.4%

The demographic detail on EMT-B respondents age groupings, provided valuable information on the maturity levels of staff deployed in the northern emirates of UAE. It must be acknowledged that there was an omission on the survey relating to the 6-8 years group, that was not included when the survey was loaded on the electronic platform, for unknown reasons. However, the majority of the respondents were in the 4 to 10-year experience grouping.

4.3.23. Response to demographic information on respondents: Emirate represented.

Table 67: The regional distribution of the respondent EMT-Bs at the time of survey.

Category	Frequency	Relative Frequency
Sharjah	103	37.6%
Ajman	62	22.6%
Fujairah	52	19%
Ras-al-Khaimah	49	17.9%
Other (please specify)	8	2.9%

Demographic representation of the respondents highlight that the majority (37.6%) was from the Sharjah Emirate, followed by Ajman Emirate (22.6%). Fujairah and Ras-Al-Khaimah Emirates responses were similar with 19% and 17.9% respectively. These figures seem to align with the area population demographics (Table: UAE Emirates in the north population distribution (ref: EDS Digital Marketing, 2020) and the Caseload stratification (Figure 2: Geographic caseload

stratification graph incl. 6-month and 12-month trends). Therefore, the results can be considered relatively representing the demographics of the regions. However, the geographical representation of respondents remains to be statistically verified

4.3.24. Response to demographic information on respondents: Operational deployment.

Table 68: The operational deployment of participating EMT-Bs at the time of survey.

Category	Frequency	Relative Frequency
Ambulance Frontline Operations	258	94.2%
Aeromedical Operations	6	2.2%
First Responder	6	2.2%
Other (please specify)	3	1.1%
Administration Role	1	0.4%

The overwhelming majority of the EMT-B respondents are allocated to 'Ambulance Frontline Operations' by 94.2%. The result highlights the EMT-Bs in the northern emirates are the frontline clinical staff. The implication on implementing capnography, in this particular group can have major impact on patient care directly. These EMT-Bs are exposed to pathologies such as Head Injuries, Respiratory Pathology and Resuscitation events in great numbers (Table 9: Caseload Pathologies in recorded in dataset) where, capnography has shown to be of value. Therefore, capnography implementation at EMT-B level can have maximum impact.

4.3.25. Response to information on respondents: Medical Qualifications / Course completion.

Table 69: The medical qualifications / course completion of the EMT-Bs at the time of survey.

Category	Frequency	Relative Frequency
EMT-B Qualification	264	94%
Nursing Degree (BSc Nursing)	262	93.2%
PHTLS (Pre-hospital Trauma Life Support) Course	251	89.3%
Basic Airway Course	242	86.1%
ACLS (Advanced Cardiac Life Support) Course	108	38.4%
PALS (Paediatric Advance Life Support) Course	83	29.5%
Resuscitation Course (Part of Extended Scope)	65	23.1%
Other (please specify)	21	7.5%

The Baseline qualifications captured in the demographic detail, highlights that majority of the respondents have EMT-B (94%), Nursing Degrees (93.2%), PHTLS (89%) and Basic Airway Course (86.1%) qualifications. The implications are that this is a well-qualified group and together with their experience levels (Table 66), coping with capnography implementation is a possibility given some of the safety concerns. Also, with the qualifications that the EMT-B majority have in hand, highlights that there would have been some degree of capnography exposure on each of the qualifications attained.

4.3.26. Response to survey question: On which category of training was there $ETCO_2$ exposure?

Table 70: $ETCO_2$ related to training categories that offered exposure.

Category	Frequency	Relative Frequency
During Short courses at National Ambulance in the UAE	190	67.6%
During training for your primary qualification in home country	94	33.5%
Online In-service training	43	15.3%
Other (please specify)	6	2.1%

The results of $ETCO_2$ related training categories that afforded EMT-Bs exposure, highlight that short-courses at National Ambulance offered the most exposure to capnography by 67.6%, a view shared by more than two-thirds of the respondents. The primary qualifications, at the respondent's home country, before coming to the UAE also offered some exposure to capnography was the view of 33.5% of the respondents.

4.3.27. Response to survey question: Through which programme(s) might you have been exposed to $ETCO_2$ Education & Training?

Table 71: The programmes that might have afforded exposure to the EMT-Bs in terms of $ETCO_2$ education and training.

Category	Frequency	Relative Frequency
Short Course: EMT-B	190	67.6%
Short Course: Basic Airway Course	165	58.7%
Short Course: PHTLS Programme	105	37.4%
Primary Qualification: Bachelors Nursing	101	35.9%
Onboarding Programme	68	24.2%
Mentorship Support Exposure	61	21.7%
Short Course: ACLS Course	53	18.9%
Primary Qualification: Bachelors Emergency Care	39	13.9%
Short Course: PALS Course	26	9.3%
Other (please specify)	6	2.1%

Table 71, highlights the courses that provided to most benefit to EMT-Bs in capnography education. This is particularly significant in determining if the Bachelors' Degree candidates were advantaged and/or utilized capnography to a greater extent or not, compared to the short courses post graduate.

4.3.28. Response to survey question: In EMS Operations, how do you normally assess a patients' ventilation status?

Table 72: The EMT-Bs normal methods of assessment of patients' ventilation status.

Category	Frequency	Relative Frequency
By visual observations (chest excursion / use of accessory muscles / skin colour etc)	252	89.7%
By listening to breath sounds with a stethoscope	241	85.8%
With the use of capnography ($ETCO_2$) (point-of-care test)	220	78.3%
With the use of pulse oximetry (SaO_2) (point-of-care test)	218	77.6%
By feeling for air movement from the patients' airway	133	47.3%
By listening for breath sounds without A stethoscope	132	47%
Other (please specify)	4	1.4%

Table 72, talks to the EMT-Bs reliance on conventional assessment tools in assessing patients' ventilations. The detail is used in discussion points is related to the determination of EMT-Bs perception of capnography significance in the EMS setting. Also, the reliability of conventional tools is put into context and leads discussion on pros and cons of tools and methods of ventilation assessment. The stats are also used to rate actual utilization of capnography compared to EMT-Bs perceived use.

4.3.29. Response to survey question: How do you synchronize (BVM) assisted ventilation with the patients breathing in emergency cases?

Table 73: The respondents' method of synchronizing assisted ventilation with patients breathing.

Category	Frequency	Relative Frequency
Watched for chest excursion and ventilated according to patient's breathing	229	81.5%
Used monitoring devices (if available) to guide support ventilation	142	50.5%
Used the BVM (valve opening) as an indicator to assist ventilation when required	107	38.1%
Administer un-synchronized breaths at the recommended rates irrespective of patient breaths	71	25.3%
Other (please specify)	6	2.1%

Table 73, data provides detail on the assisted ventilation trends among EMT-Bs. This is helpful in understanding practice preferences and the rating of capnography as a POCT tool in ventilation. The statistics also provide value in comparing actual versus perceived value of $ETCO_2$ monitoring by EMT-Bs in the field.

4.3.30. Response to survey question: Do you find using capnography ($ETCO_2$) helpful in managing patients in any of the categories listed below?

Table 74: The EMT-Bs perception on usefulness of capnography monitoring in various patient categories.

Category	Frequency	Relative Frequency
Cardiopulmonary Resuscitation (CPR) Events	251	89.3%
Medical (Respiratory Difficulty, Asthma/COAD)	246	87.5%
Trauma (Head Injury, Chest Injury, Multiple Trauma)	234	83.3%
Covid-19 Cases	177	63%
Psychiatric (OD/Hyperventilation)	132	47%
General Cases	82	29.2%
Other (please specify)	5	1.8%
Not Applicable (I have not used capnography in UAE)	1	0.4%

Table 74, provides good detail on the perceived value of $ETCO_2$ monitoring by EMT-Bs, according to specific pathologies. This can also be rated against industry identified uses of capnography and relates to knowledge, skills and attitudes of the study group.

4.3.31. Response to survey question: In which of the patient categories listed below would you like to see more education and training for capnography ($ETCO_2$) use?

Table 75: The EMT-Bs perception on the requirements for more education and training in capnography ($ETCO_2$) use.

Category	Frequency	Relative Frequency
Trauma (Head Injury, Chest Injury, Multiple Trauma)	232	82.6%
Medical (Respiratory Difficulty, Asthma/COAD)	228	81.1%
Cardiopulmonary Resuscitation (CPR) Events	219	77.9%
Covid-19 Patients	195	69.4%
Psychiatric (OD/Hyperventilation)	156	55.5%
Other (please specify)	4	1.4%

The results of the survey question on the need for more education and training, highlight the pathology specific needs. It is evident that the perceived needs are that more training across all pathology categories are required. Trauma and medical cases as well as CPR events rated the highest needs.

4.3.32. Response to survey question on: Are there any factors that may encourage you to use Capnography in future?

Table 76: EMT-Bs perception on factors that may encourage future capnography use.

Category	Frequency	Relative Frequency
Further Education / Training	225	80.1%
Exposure through practice	182	64.8%
Management Support (through policy & procedure)	181	64.4%
Guidelines Clarity	169	60.1%
Audit Feedback	88	31.3%
Peer Support	50	17.8%
Other (please specify)	3	1.1%

The survey response of the factors that will encourage future use of capnography are significant in this study. This particular feedback does not necessarily identify gaps, but more so the respondents' perception of what they need at this point in time to encourage use of capnography. Education and training are perceived as the biggest need (80.1%). The listed factors will need to be interrogated to a greater extent, for action to meet the needs of the EMT-Bs, if capnography will be adopted into their scope of practice.

4.4. Correlations Phase 3

4.4.1. Exposure vs. Coping/Safety

Question 34 (Have you received any exposure to education on $ETCO_2$ / Capnography?) vs. Question 10 (Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?)

Table 77: Receipt of any exposure to education on $ETCO_2$ / Capnography vs. Adequacy of trained to cope with capnography ($ETCO_2$) at EMT-B level.

	No	Yes	Yes %
Definitely I can cope easily (No further training or support required)	1	6	86
Yes, I can cope (adequately)	9	91	91
Most times I can cope (further training and support will help)	27	86	76
Not really (I need further training and support)	10	22	69
Not at all for BLS level of care (too much for me)	0	1	100

Fishers Exact Test of Independence pp-value: 0.00792: relationship is statistically significant at 5% level. Exposure is related to perception of adequate education. This highlights the afforded exposure to $ETCO_2$ education and the confidence of the EMT-Bs in taking up $ETCO_2$ Technology at Basic Life Support (BLS) level. These results form part of the discussion on the knowledge gaps and safety of capnography use. Detail is also used in opportunity potential and risk mitigation argument.

4.4.2. PHTLS Qualification vs. Care Categories - Trauma

Question 9 (Please select the Medical Qualifications / Courses that you have completed from the list below PHTLS (Pre-hospital Trauma Life Support) Course) vs. Question 27 (Do you find using capnography ($ETCO_2$) helpful in managing patients in any of the categories listed below? Trauma (Head Injury, Chest Injury, Multiple Trauma).

Table 78: PHTLS Qualification vs. Care Categories – Trauma

	No	Yes	Yes %
Trauma - Yes	17	217	93
Trauma - No	13	34	72

Fisher's Exact Test of Independence pp-value: 0.000231: relationship is statistically significant at 5% level. This highlights Trauma Education and perception of $ETCO_2$ helpfulness in managing Trauma Patients are related. This data is particularly interesting, in that capnography use has been advocated in managing Traumatic Brain Injury (TBI) trauma patients. The correlation between trauma education and perceived capnography usefulness in trauma patients, highlights education value and may be used to direct futures strategies in skill enhancements.

4.4.3. Basic Airway Qualification vs. Care Categories - Medical

Question 9 (Please select the Medical Qualifications / Courses that you have completed from the list below Basic Airway Course) vs. Question 27 (Do you find using capnography ($ETCO_2$) helpful in managing patients in any of the categories listed below? Medical (Respiratory Difficulty, Asthma/COAD).

Table 79: Basic Airway Qualification vs. Care Categories – Medical

	No	Yes	Yes %
Medical - Yes	25	221	90
Medical - No	14	21	60

Fisher's Exact Test of Independence pp-value: 3.05e-05: relationship is statistically significant at 5% level. The Basic Airway Course is perceived to have some positive relationship with $ETCO_2$ use in managing medical patients. Again, the value of an education activity is rated with $ETCO_2$ use to draw attention to the value of the course in supporting $ETCO_2$ use and can be used to enhance EMT-B skills in future, if required.

4.4.4. ACLS Qualification vs. Care Categories - Medical

Question 9 (Please select the Medical Qualifications / Courses that you have completed from the list below ACLS (Advanced Cardiac Life Support) Course) vs. Question 27 (Do you find using capnography ($ETCO_2$) helpful in managing patients in any of the categories listed below? Medical (Respiratory Difficulty, Asthma/COAD).

Table 80: ACLS Qualification vs. Care Categories – Medical

	No	Yes	Yes %
Medical - Yes	145	101	41
Medical - No	28	7	20

Fisher's Exact Test of Independence pp-value: 0.0163: relationship is statistically significant at 5% level. Although the ACLS course encourages the use of capnography in the programme, it is mainly advocated in cardio-pulmonary resuscitation scenarios. Education on the respiratory pathologies is limited. However the concept and exposure to capnography is brought into question here.

4.4.5. Resuscitation qualification vs. Care Categories - CPR

Question 9 (Please select the Medical Qualifications / Courses that you have completed from the list below Resuscitation Course (Part of Extended Scope) vs. Question 27 (Do you find using capnography ($ETCO_2$) helpful in managing patients in any of the categories listed below? Cardiopulmonary Resuscitation (CPR) Events).

Table 81: Resuscitation qualification vs. Care Categories – CPR

	No	Yes	Yes %
CPR - Yes	190	61	24
CPR - No	26	4	13

Fisher's Exact Test of Independence pp-value: 0.252: relationship is not statistically significant at 5% level. This correlation result highlights that the Resuscitation Course that the respondents participated in and the perceived value of $ETCO_2$ use does not show association. This correlation is not significant yet, $ETCO_2$ monitoring and CPR should be closely related. This may signify that capnography was not covered in the extended scope programme and identifies a gap or missed opportunity in training.

4.4.6. Origin of Qualification vs. Coping/Readiness

Question 11 (Through which programme(s) did you receive $ETCO_2$ exposure? During training for your primary qualification in home country) vs. Question 34 (Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?).

Table 82: Origin of Qualification: Home Country vs. Coping Readiness

	No	Yes	Yes %
Definitely I can cope easily (No further training or support required)	5	2	29
Yes, I can cope (adequately)	58	42	42
Most times I can cope (further training and support will help)	79	34	30
Not really (I need further training and support)	24	8	25
Not at all for BLS level of care (too much for me)	1	0	0

Fisher's Exact Test of Independence pp-value: 0.239: relationship is not statistically significant at 5% level. The information here speaks to the readiness of EMT-Bs to deal with $ETCO_2$ as a POCT tool. This is included in the discussion and also has safety implications in patient care and crew confidence levels to use new technology.

4.4.7. Origin of Qualification: UAE Short Course vs. Coping Readiness

Question 11 (Through which programme(s) did you receive $ETCO_2$ exposure? During Short courses at National Ambulance in the UAE) vs. Question 34 (Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?).

Table 83: Origin of Qualification: UAE Short Course vs. Coping Readiness

	No	Yes	Yes %
Definitely I can cope easily (No further training or support required)	3	4	57
Yes, I can cope (adequately)	19	81	81
Most times I can cope (further training and support will help)	37	76	67
Not really (I need further training and support)	12	20	62
Not at all for BLS level of care (too much for me)	1	0	0

Fishers Exact Test of Independence pp-value: 0.0252: relationship is statistically significant at 5% level. There seems to be a statistical relevance of the UAE Short Course training and the perception of readiness for $ETCO_2$ use. This is significant, in that it highlights that one does not need a degree to be able to cope with capnography use, even if it is a new enhancement in scope of practice.

4.4.8. Origin of qualification: Online In-Service vs. Coping Readiness

Question 11. (Through which programme(s) did you receive $ETCO_2$ exposure? Online In-service training) vs. Question 34 (Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?

Table 84: Origin of qualification: Online In-Service vs. Coping Readiness.

	No	Yes	Yes %
Definitely I can cope easily (No further training or support required)	4	3	43
Yes, I can cope (adequately)	82	18	18
Most times I can cope (further training and support will help)	98	15	13
Not really (I need further training and support)	29	3	9
Not at all for BLS level of care (too much for me)	0	1	100

Fishers Exact Test of Independence pp-value: 0.0447: relationship is statistically significant at 5% level.

4.4.9. Experience Level vs. Coping Readiness.

Question 5 (Years of Experience (Simplified) vs. Question 34 (Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?

Table 86: Experience Level vs. Coping Readiness.

	0 - 4 Years	4 - 10 Years	> 10 Years
Definitely I can cope easily (No further training or support required)	1	5	1
Yes, I can cope (adequately)	16	75	9
Most times I can cope (further training and support will help)	15	94	4
Not really (I need further training and support)	5	20	7
Not at all for BLS level of care (too much for me)	0	0	1

Fishers Exact Test of Independence pp-value: 0.014: relationship is statistically significant at 5% level.
Comment: it actually appears that those with less years of experience tend to be more likely to report that they are coping better. This could suggest that training has improved in recent years or recent introduction of training but not further interrogated.

4.4.10. Exposure to $ETCO_2$ Training vs. Safety perception coping.

A new variable was created which was 'Yes' if the respondent had indicated in Q 12 that they were exposed to $ETCO_2$ training in at least one of the listed programmes, and 'No' otherwise. Question 12 (Exposed to $ETCO_2$ Training in at least one way) vs. Question 34 (Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level?)

Table 87: Exposure to $ETCO_2$ Training vs. Safety perception coping

	No	Yes	Yes %
Definitely I can cope easily (No further training or support required)	1	6	86
Yes, I can cope (adequately)	9	91	91
Most times I can cope (further training and support will help)	27	86	76
Not really (I need further training and support)	10	22	69
Not at all for BLS level of care (too much for me)	0	1	100

Fisher's Exact Test of Independence pp-value: 0.00792: relationship is statistically significant at 5% level. This again highlights the value of training and education on confidence levels of basic level staff to cope with new interventions with safety implications.

4.4.11. Pressure vs. Diagnostics

Question 32 (How much pressure do you feel from your superiors to use capnography ($ETCO_2$)?) vs. Question 33 (Have you ever been in a situation where you connected up the $ETCO_2$ sampling line to the monitor and got a value of $ETCO_2$ but did not use the information further to direct treatment?)

Table 88: Pressure vs. Diagnostics.

	A lot of pressure	Significant pressure	Little pressure	No Pressure
Always	0	1	0	0
Often	1	4	10	4
Occasionally	0	7	40	26
Never	1	15	33	54

Fisher's Exact Test of Independence pp-value: 0.00313: relationship is statistically significant at 5% level.
Comment: it does appear that the more one feels pressure from one's superiors to use $ETCO_2$, the more likely the situation is to happen where $ETCO_2$ diagnostic info is not used in treatment.

4.4.12. Pressure vs. Coping.

Question 32 (How much pressure do you feel from your superiors to use capnography ($EtCO_2$)?) vs. Question 34 (Are you adequately trained to cope with capnography ($EtCO_2$) technology at BLS Level?)

Table 89: Pressure vs. Coping.

	No pressure	Little pressure	Significant pressure
Not really/Not at all	13	15	5
Most times I can cope (further training and support will help)	36	59	18
Yes, I can cope (adequately)	51	32	17
Definitely I can cope easily (No further training or support required)	6	1	0

Fisher's Exact Test of Independence pp-value: 0.0179: relationship is statistically significant at 5% level. Comment: those who reported pressure from superiors to use $ETCO_2$ were more likely to report that they are not adequately trained to cope.

4.5. Relationships (between Phase 2 and Phase 3)

Note: the Phase 2 data set was correlated with the survey data set using the employee ID as the primary link. There were case records in the phase 2 data for the 281 of the employees that participated in the survey and correlations was made possible using the linking strategy.

4.5.1. Nursing Degree vs. $ETCO_2$ Utilisation

Table 90: Nursing Degree vs. $ETCO_2$ Utilization.

	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
Nursing Degree	19935	850	4.09
No Nursing Degree	1091	34	3.02

There is not a statistically significant relationship between nursing degree status and $ETCO_2$ utilisation (pp-value: 0.08640.0864).

4.5.2. $ETCO_2$ Utilisation by Perception of Value (Q 27)

Here, a new binary variable was created, which is 'No' if the respondent did not indicate that $ETCO_2$ is helpful in any of the categories (CPR, Medical, Trauma, COVID-19, Psychiatric, General, Other) and 'Yes' if the respondent indicated that it is helpful in at least one category.

Table 91: $ETCO_2$ Utilization by Perception of Value.

	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
No	1716	146	7.84
Yes	19310	738	3.68

There is a statistically significant relationship between perception of value and $ETCO_2$ utilisation (pp-value: 3.23×10−153.23×10−15). Strangely, it appears that those who are less likely to consider $ETCO_2$ helpful are more likely to use it! Not further interrogated due to defined scope.

4.5.3. $ETCO_2$ Utilisation by Difficulty Breathing/Asthma Diagnostic Ability (Q 20).

Table 92: $ETCO_2$ Utilization by Difficulty Breathing/Asthma Diagnostic Ability

	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
Correct	8869	383	4.14
Incorrect	10497	361	3.32

There is a statistically significant relationship between getting Question 17 correct and $ETCO_2$ utilisation (pp-value: 0.002390.00239). It appears that those who got this question correct are slightly *more* likely to use $ETCO_2$.

4.5.4. $ETCO_2$ Utilisation by Availability of Tools (Q 29)

Table 93: $ETCO_2$ Utilization by Availability of Tools

	$ETCO_2$ Not Used	$ETCO_2$ Used	% $ETCO_2$ Used
Always	7059	356	4.8
Usually,	7648	234	2.97
Occasionally	4565	147	3.12
Never	24	1	4

There is a statistically significant relationship between availability of tools and $ETCO_2$ utilisation (pp-value: 7.4×10−97.4×10−9). The 'Never' group is too small to read much from; the main finding here is that the 'Always' group in terms of availability of tools is slightly more likely than the 'Usually' or 'Occasionally' groups to utilise $ETCO_2$.

4.6. Synopsis of results in Section 4

The second phase of the results on demographic detail provided a clearer perspective of the prevalence of the pathologies in the northern emirates of the UAE and also provided some context to the results observed. The high caseloads observed in the Sharjah Emirate compared to other emirates aligns with the demographics of the area and also draws attention to the maldistribution of caseload and the geographical bias of capnography exposure to cases. The results from the retrospective analysis also shows the trauma cases as the leading pathology in the area with motor vehicle accidents at the top of the list, bearing in mind that the time-period of the data-set was in the pre-Covid-19 era in the UAE. The dataset also mainly focused on pathologies of head injury, respiratory pathologies, psychiatric cases, cardio-pulmonary resuscitation cases, trauma and other cases where capnography has shown to have significance. Bearing in mind that the study is pitched at a Basic level of care for EMT-Bs, the potential uses for $ETCO_2$ monitoring also has to curtailed to the very level of care as well. The numbers in each of the pathologies showed significant proportions of pathology where capnography could have been used and where it actually was used and by whom and is detailed in the discussion section.

A synopsis of $ETCO_2$ use by EMT-Bs with Head and neck injuries showed 1.65% use, Breathing difficulty 19.88% use, Trauma/Assault cases 2.73%, Mental/Emotional and Psychological cases with 2.09% use and the other case categories at 4.52% use. Although, these numbers look small but considering percentage proportion the population sample size of 37 950, the numbers are

significant. The opportunity for $ETCO_2$ monitoring in these potential cases was highlighted at 62.63 cases per staff member but actual performed $ETCO_2$ POCT/monitoring was conducted at 2.53 cases per staff member (not considering the maldistributed opportunity). The results also showed that 326 EMT-Bs that attended at least 30 potential cases, performed at least one set of $ETCO_2$ observations. The mean time spent with $ETCO_2$ patients was higher with higher (37.86 min) compared to the time spent with patients where no $ETCO_2$ was observed (34.54 min.).

The CPR case result analysis was interesting in that $ETCO_2$ as a POCT test was performed on 52.2% of the resuscitation cases and, those that had airway maintenance adjuncts (SGA's) in place, 54.77% of them were monitored with $ETCO_2$. While external compression with a mechanical device (compressor), $ETCO_2$ was observed in 53.09% of the cases. The use of $ETCO_2$ is of particular significance in external cardiac compressions as a quality measure and $ETCO_2$ use with ROSC was observed at 62.04% of the cases. Also interesting is that $ETCO_2$ use observed with less than 10 mmHg was 45.85%, $ETCO_2$ recordings with greater than 20 mmHg was at 57.52% and $ETCO_2$ with increasing trends in non-ROSC patients was at 86.23% and 92.5% with ROSC. These results are elaborated in the discussion.

Capnography/$ETCO_2$ was also shown to be used on conscious, fully alert patients at a rate of 3.27% of the cases. Patients with respiratory rates of less than 10 (bpm) and greater than 20 (bpm) were also significantly higher with Asthma patients enjoying a 27.68% use of $ETCO_2$ monitoring. The use of the $ETCO_2$ with respiratory assist device (BVM) was at 49.34% and in a resuscitation scenario with BVM use $ETCO_2$ was used in 54.01% of the cases.

The Phase 2 of the results highlighted the actual usage trends of $ETCO_2$ by the study and although utilization was low for most scenarios, there was positive signs of appropriate and effective use of $ETCO_2$ in the pathologies where $ETCO_2$ use was shown to be of some value. In the resuscitation cases, the use of $ETCO_2$ was significantly higher than other categories and also aligned to positive outcomes proven by other research (ILCOR) and highlights that capnography value is being acknowledged even at EMT-B level of care. The detail in the results were quite comprehensive and will be covered more extensively in the discussion. The overall results (Phase 2) point towards the EMT-B cohort having the ability to use the POCT $ETCO_2$ tool appropriately but, the utilization rates remain low.

Continuing to synopsis of the (Phase 3) results that covered the exposure, self-perceived value, diagnostic value, support, biases and safety of $ETCO_2$ use by EMT-Bs. The majority of the EMT-Bs in the frontline operations in the northern emirates (94.2%) acknowledge receiving some degree of exposure to $ETCO_2$/capnography education (81%). Although operating at an EMT-B level these staff have Nursing Degrees (94%) and EMT-B qualifications (100%) and there was no bias in capnography use if the EMT-B had a degree qualification or not. The majority of the EMT-Bs still

use the conventional methods of assessing patient ventilations by observing chest excursions (89.7%) or using the stethoscope (85.8%). A large contingent (78.3%) also proport to use capnography in assessment of ventilations but this is not congruent to actual utilization rates observed in historical trends (4.98%).

In line with recommended practice for capnography use, EMT-Bs showed an appreciation and possible use of capnography in, the placement of Supra-glottic Airways (SGAs) (79.8%), as a tool to guide ventilation using the Bag Valve Mask (BVM) (93.3%), to manage Traumatic Brain Injury (TBI) Patients (93.8%), to monitor quality of Cardio-Pulmonary Resuscitation (CPR) (97.2%) and to predict the possible outcome of a CPR event (94.5%) despite limited exposure, training and education at a EMT-B level of care. The diagnostic value derived from scenario-based question also highlighted the appropriate use of capnography as a POCT Tool and some instances where results were not quite as expected and may have been attributed to confounding factors that were not further tested.

Emerging trends of capnography use was also considered, and EMT-Bs showed some appreciation of its' use albeit at a lower rate of acknowledgement. Feedback received from EMT-Bs related possible capnography use to, monitor spontaneous breathing fully alert patients (65.6%) and to determine the risk of deterioration in Covid-19 patients (87.9%).

In general capnography use in the diagnostic detection of Return of Spontaneous Circulation (ROSC) (66,8%), the diagnostic detection of hypoventilation in the treatment of TBI patients (61.3%) were identified by EMT-Bs. While the diagnostic detection of broncho-constriction (44.1%) and diagnostic value of adequate CPR being performed were not so well interpreted. Given that there may be confounding factors for these findings, there opportunity presents, to deal with the possible gap in interpretation to make for safer practice at EMT-B level of care.

Capnography was found to be easy to set-up and to use in the pre-hospital setting, at EMT-B level. It is encouraging that most EMT-Bs (74%) feel with certainty, that capnography can help them deal with some of the patient conditions that they are exposed to, in the northern emirates of UAE, and that the education and training exposure that they received was very useful (74.4%). Although, a structured capnography programme on its own, is yet to be constructed in the current operation.

The Patient Care Protocols (CGP 134) guidelines were found to be mostly adequate (71.3%) but also presents the opportunity for revision, if capnography is going to be included at EMT-B level of practice. This should be considered together with a monitoring and audit system to encourage safe practice and ensure quality standards.

From a safety perspective most EMT-Bs felt little or no pressure, in being forced to use capnography (84.2%). While some respondents (36.4%) observed capnography values but

occasionally and often did not use the information to further treat the patient. The reasons for the non-use of the capnography results were not further investigated at this stage. It must also be reported that perceived unreliable or inaccuracy in capnography recording are occasionally experienced as perceived by 43.5% of the respondents, and this is concurrent with literature findings that capnography should be viewed as an adjunctive tool in decision making and patient condition should be considered wholistically. Therefore, this result was expected and would be cause for concern if it was not detected.

Although there was no gender bias detected (statistically) with the use of capnography in the local population, there may be greater opportunity in the UAE to afford a more conservative approach in assessing patients and also providing objective parameters in patient assessments. In this vain the EMT-Bs need to have the tools to do the job, and the presence of the capnography accessories availability was found to be 71.5% available to frontline EMT-Bs but, this should be closer to 100% to encourage future use.

EMT-Bs were of the opinion that they can most times (44.7%) and adequately (39.5%) cope with capnography use at EMT-B level of care, but acknowledge that further training and support will help them with capnography use. Education and training stand out as the overall greatest need (80.1%), in all identified categories of capnography use by EMT-Bs surveyed.

These finding highlight the value of capnography at an EMT-B level of care in the front-line. As a POCT tool, EMT-Bs are of the opinion that capnography can help them deal with patients in their care. With more training and support the possibility of capnography inclusion in the EMT-B scope of practice can be attained. Safety and quality measures will also need to be considered if capnography was to be implemented formally at this level of care. The potential of capnography to support EMT-B diagnostic ability in northern emirates (UAE) augers well for prehospital diagnostic capability.

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Chapter 5 – Discussion

5.1 Purpose of the Study:

The study set-out to address the gaps in the knowledge, of how the diagnostic capability of EMT-Bs may be altered by the enhancement of POCT capnography, as well as the perceived value of the $ETCO_2$ diagnostic tool. In the context of EMT-Bs scope of practice operating in the UAE, the relationship between POCT capnography and diagnostic capability is undocumented in this population. Such knowledge could inform how enabling[11] or burdening[12] scope changes can be for EMT-Bs. This study is about Point-of-Care Testing focused on Capnography. We have learnt from the literature review, that with the advent of technology, that capnography as with other POCT tools, are becoming more accessible, and that future practice will be led by these types of innovations (Basis, 2009). It is also understood that the EMT-B level of ambulance workers, practice at Basic level of care, given their limited scope of practice and training (National Highway Traffic Administration (NHTA no date; OH Abu Dhabi, 2020). Combining advances in technology and enhanced practice begs the question: "How does the point of care testing (POCT) through capnography, enhance the diagnostic capability of EMT-Bs in the UAE?" The perceptions of the EMT-Bs that have exposure to the enhanced POCT capnography, can help answer these questions from first-hand experiences in practice. In terms of these developments in a changing scope, we need to then interrogate the implications and ask: What do these changes mean for EMT-B practice?

[11] Enabling, referring to capnography as a POCT tool use that can positively support (help) EMT-Bs with quick and accurate measures of $ETCO_2$ that will aid swift and confident decision making.

[12] Burdening (converse to enabling), refers to capnography as a POCT tool that hinders or distracts EMT-Bs from clinical decision making, with negative impact (less accurate decision making) and can be considered adding unwarranted stress to the clinician.

5.2 Objectives and Emergent Questions

Objectives	Emergent Questions	Purpose	Method
To provide an epidemiological description of $ETCO_2$ application by EMT-Bs'.	What are the records reflecting on the adoption of $ETCO_2$ use by EMT-Bs in the UAE?	To evidence the uptake of capnography as an POCT tool in the EMT-B enhancement process.	Archival research: Trend analysis from retrospective patient medical records
To document the EMT-Bs self-perception of the inclusion of $ETCO_2$ into their clinical scope.	What has been the EMT-Bs exposure and perceptions of $ETCO_2$/Capnography in support of their diagnostic abilities?	To determine if POCT capnography is helpful or a hindrance at EMT-B level, and can they take on capnography as a POCT tool going forward.	Prospective survey: Self - directed questionnaire with EMT-Bs in the northern emirates of UAE.
To provide context to task shifting in settings of greater need than resources availability, while exploring opportunities and risks	What are the opportunities presented and risks?	To determine the support that EMT-Bs may require for safe capnography use to be sustained.	Literature Review on behaviour change in adopting new skills recommendations

Repeat Table 1: Objectives & Emergent Questions (as reminder)

5.3. Methods and Procedures

Phase 1 involved a literature review. An extensive narrative analysis explicated the factors associated with POCT capnography, and prehospital diagnostic practice. The literature review informed the problem description and factor analysis to be considered in Phase 2. In the second phase, a review of electronic patient care records was conducted to determine the quantitative trends of capnography utilisation, albeit retrospectively. Understanding capnography practice from medico-legal records informed the survey parameters and provides insight of the EMT-Bs past practice trends using $ETCO_2$. Phase 3 involved using a prospective, descriptive, online survey, to attain quantitative data on capnography experiences and perception of the EMT-Bs in using $ETCO_2$ to support their diagnostic skills.

Objective 1: To Provide an epidemiological description of $ETCO_2$ application by EMT-Bs.

5.4. What are the records reflecting on the adoption of $ETCO_2$ use by EMT-Bs in the UAE?

5.4.1. General trends of opportunity and use of capnography in the northern emirates (UAE).

Analysis of historical data retrieved from National Ambulance records for the northern emirates of UAE, reveal caseload records (with potential for $ETCO_2$ use) between the periods of 01 March 2019 to 29 February 2020, to be 39 937 recorded events (Table 8). Clinical Pathology Categories of Head Injuries, Respiratory Pathologies, Cardio-Pulmonary Resuscitation (CPR) cases and any other case categories, where there was a potential for capnography use was included in this study. Therefore, the database of emergency calls analysed was limited to cases where there was a potential for $ETCO_2$ use and did not reflect the full actual EMS total case load of the area. The data mined from patient care records serve to highlight the potential opportunities for capnography use, that existed in the northern emirate setting where advanced emergency medical care resources are limited. Given the introduction of POCT capnography to the EMT-B level of practice, provided an ideal opportunity to study the perceptions and diagnostic ability implications of such an intervention, when shifted to a lower cadre of clinical staff, opposed to the POCT tool being reserved only for advanced care practitioner use. The caseload data retrieved, was further stratified according to regional locations (5 Northern Emirates) in order to compare regional variations, and highlighted significantly more activity and also opportunity for $ETCO_2$ use in the Emirate of Sharjah, being the 3rd largest and proportionately industrialized emirate of the UAE (Graph 1). The stratification was necessary to identify opportunity versus trends in capnography utilization within the geographical region as well as the distribution of pathology trends (Graph 3). Data analysis revealed a regional bias of $ETCO_2$ monitoring use. A Pearson chi-square test of independence was conducted to check for an association between the emirates and $ETCO_2$ utilization trends. The conclusion at the 5% significance level was an association between the emirates and $ETCO_2$ utilization (p-value: 1.17×10^{-12}). Specifically, capnography/$ETCO_2$ use appeared to be highest in Sharjah and lowest in Ras Al Khaimah and Umm Al Quwain (Table 37). This result also correlates with the potential exposure rates (Table 8). The implications of these finding are that EMT-Bs operating in the Sharjah area were exposed to a higher caseload with potential for capnography use compared to the other regions. The uptake of capnography utilization in the emirate of Sharjah was also proportionately higher according to regional trends (Table 21). A regional trend detailed analysis helped to identify which regions were more likely to use POCT $ETCO_2$ independent of frequency of exposure. A Pearson chi-square test of independence was conducted to check for an association between region and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is an association between region and $ETCO_2$ utilization (p-value: 1.17×10^{-12}). It was found that the Emirate of Sharjah was associated with greater $ETCO_2$ usage trend than the Emirate of Umm-Al-Quwain, with the least usage at 3.76%. Therefore, independent of the other variables such as knowledge, skills, attitude and resource availability, the analysis shows that the uptake of capnography use was influenced by geographical location. This provides context to the results of

the study and highlights the bias in regional trends and also points out user location as a confounding factor in EMT-B capnography utilization.

The pre-hospital clinical emergency care is considered being in the 'Infancy' stage, especially so in the middle-east (Fares *et al.*, 2014). Pre-hospital capnography use as a POCT tool is also considered in early stages of development (Wylie, Welzel and Hodkinson, 2019). Without being formally adopted in the EMT-B scope of practice, the practitioner enhanced skill trends of use was also analysed. The capnography trend analysis looked at the frequency of the overall usage statistics across all cases that were taken from the database with any potential of $ETCO_2$ monitoring (Section 1.8.6 – Inclusion Criteria). The results highlighted the overall utilization rate of 4.98% of the patient categories assessed. Although, the utilization rate was considered as low, there was no baseline or norm value that could be referenced from literature. Therefore, there was no established marker to compare this statistic observed in the EMS system, let alone at EMT-B level. Technically, any and every patient could be monitored with POCT capnography which, some consider as an additional vital sign (Wright, 2017) but the practicality and feasibility of routine POCT may be questioned.

Head Injuries, Respiratory pathologies, Trauma, Psychiatric, Resuscitation and other cases of interest show significant numbers and opportunity for $ETCO_2$ monitoring in the analysis. This highlights the potential exposure to case events where $ETCO_2$ monitoring could have been used to assist diagnostic skills by the EMT-Bs in this study. However, $ETCO_2$ monitoring was used in only 4.98% of the events overall (Table 16). The mean number of incidents attended per EMT-B was 62.63 and the median was 50. The mean number of $ETCO_2$ performed per employee was 2.53 and the median was 1. The frequency of EMT-Bs who performed at least one $ETCO_2$ was very positive, at 71.33% focusing only on employees who attended at least 30 incidents (which is about 2/3 of all employees). This highlights that given the frequency of exposure staff will be more likely to use POCT $ETCO_2$ (Table 20). However, the distribution of usage among EMT-Bs show that just over 150 EMT-Bs (50%) received more exposure to case incidents with potential for $ETCO_2$ monitoring and represents maldistributed opportunity (Histogram 1). The generally low utilization of $ETCO_2$ remains the concern and relates to the uptake of capnography.

5.4.2. Capnography use in general trauma cases in the northern emirates (UAE).

$ETCO_2$ monitoring is shown to play a role in trauma related pathologies. Traumatic Brain Injury (TBI) has frequently been highlighted for capnography monitoring however, research also highlights other trauma related pathologies like Shock (Wemplar, 2011), ventilation in the trauma patient (Helm, *et al.*, 2003), trauma triaging (Williams, *et al.*, 2016), that POCT capnography can be useful to support. $ETCO_2$ monitoring is also significant in treatments of these patients

including pain relief and/or sedation where respiratory complications can be closely monitored with the use of $ETCO_2$ (Aminiahidashti, *et al.*, 2018)

The recoded potential for capnography case events (observed over the study period) was also analysed and were stratified using the National Ambulance working diagnosis categories that highlight case categories (Annexure H). The findings showed that Road Traffic Accidents (RTAs) dominated the trends as the leading number (10 534) of case frequency recorded (Table 9) with the Assault/Trauma category of patients accounting for the 2nd highest rate of pathologies recorded 4762 events in the study period. These finding are concurrent with previous research in the UAE (Fares, *et al.*, 2014). Road traffic accidents ranked as the second leading cause of death after cardiac events in the UAE (Fares, *et al.*, 2014). This study has excluded cardiac events, from the identified pathologies where capnography use has been shown to have value. Capnography monitoring related to the cardio-vascular system can be used highlight low cardiac outputs, decreased perfusion, cardiogenic shock, pulmonary embolus and patient response to fluids (etc.) but this study focuses on the EMT-Basic level of care (Johnson, Schweitzer and Ahrens, 2011; Long, Koyfman and Vivirito, 2017). Except, Cardiopulmonary Resuscitation (CPR) events were recorded separately. RTA's being the leading case load recordings together with trauma is in line with other publications (Fares, *et al.*, 2014).

The use of capnography in general trauma patients is controversial. A study (in 2016) reported an association of $ETCO_2$ of ≤ 30 mmHg to be associated with increased risk of severe traumatic injuries. However, $ETCO_2$ may not be used to rule out severe injuries meeting trauma care centre criteria (Williams, *et al.*, 2016). In trauma patients with shock, patients may present with low levels of $ETCO_2$ and may not be reflective of the actual CO_2 levels in the patient (Aminiahidashti, *et al.*, 2018). The use of $ETCO_2$ monitoring in trauma or particularly in patients that are in shock was also investigated, despite the controversy of the reliability of its ($ETCO_2$) use. Historical trends show that $ETCO_2$ monitoring has been used in just over 5% on patients with some degree of shock. The mean shock index (SI) among non-$ETCO_2$ patients was 0.63. The mean shock index among $ETCO_2$ patients was 0.45. It was concluded that the mean shock index was lower among $ETCO_2$ patients (p-value of $2.1115793 \times 10^{-98}$). This result shows that capnography was used more for patients with a lower shock index.

Capnography use for shock patients, has also been controversial due to perfusion related and mixed pathology reasons. Whilst some studies show potential for $ETCO_2$ use with hypotension and acidaemia but require more research (Williams, *et al.*, 2016; Aminiahidashti, *et al.*, 2018). As an alternative more reliable method of detecting shock, National Ambulance has an inbuilt formula loaded on the tool used to collect electronic Patient Care Records (PCRs). The tool calculates the Shock Index (SI) automatically when the patient related data are inputted to the device. If a value greater than 0.9 is observed, the patient is in a state of shock. The Shock Index

(SI) has been a reliable indication of shock and warns the medical crew of the patient disposition when a score indicating that the patient data signals signs of shock. Therefore, $ETCO_2$ monitoring of these cases (trauma with shock) may be given less significance in the local setting.

In other studies the importance of capnography with airway control in trauma patients was pointed out (Helm, *et al.*, 2003). At EMT-B level this may have some significance in the obtunded patient where medical crew are managing the airway and oxygenation of the patient. In mitigation of the rarity of adequate ventilation being achieved in pre-hospital trauma patient management, capnography has been cited as an alternative tool to guide ventilations for severe trauma patient (Helm, *et al.*, 2003). Therefore, while capnography in the trauma patient with shock may be unreliable, it may have value in specific areas of dealing with trauma patients like with airway and ventilation control, and or head injury patients.

There are various uses of capnography in the pre-hospital setting (Basis, 2009; Masimo, 2013). Beside the trauma patient, the current study analysed some of the potential cases where capnography could have been used by the EMT-Bs to manage patient care.

5.4.3 Capnography use with airway control (Supra-Glottic Airways)

Capnography has been shown to play a confirmation role of advanced airway placement in endotracheal tube (ETT) placement (Pantazopoulos, *et al.*, 2015) and has become a gold standard by the American Heart Association (AHA) (Link, *et al.*, 2015)[13]. The research on SGA placement confirmation of placement is limited. The EMT-Bs at National Ambulance are permitted to place Supra-glottic Airways (SGA) for patients that are being resuscitated or unconscious patients that cannot protect their airways. This presents another opportunity for the use for $ETCO_2$ monitoring. Unfortunately, in the American Heart Association (AHA) Resuscitation Guideline 2015 review, there were no actual studies conducted that tested the efficacy of $ETCO_2$ monitoring for confirmation of placement of these (SGA) adjuncts (Link, *et al*., 2015). However, in the update revision of the ILCOR Guidelines (2015), it was highlighted that continuous waveform capnography 'could' be used for sampling of an SGA or an airway with a leak. So, in the proposed $ETCO_2$ study this variable (SGA positioning) could also be analyzed as an option. In the absence of other objective confirmation methods, it is accepted that $ETCO_2$ POCT can be used to monitor placement of these airway adjuncts (SGAs).

The analysis of the historical data in the study revealed that an SGA was placed by EMT-Bs in 692 cases of the total 774 CPR cases, and 54.77% of the cases used $ETCO_2$ with the SGA and CPR. The

[13] The significance of this analysis is that $ETCO_2$ has been shown to play a confirmation role of advanced airway placement in Endotracheal tube (ETT) placement (Pantazopoulos, *et al.*, 2015) and has become a Gold Standard by the American Heart Association (AHA) (Link, *et al.*, 2015)

high correlation of $ETCO_2$ use with SGAs in CPR Cases are significant to this study (Table 24). A Pearson chi-square test of independence was conducted to check for an association between CPR & SGA utilization and $ETCO_2$ utilization. The conclusion at the 5% significance level was that there is an association between CPR & SGA utilization and $ETCO_2$ utilization (p-value: 5.23×10^{-5}). This highlights that at EMT-B level, SGAs with capnography are being used for more than half of all the resuscitation cases in the northern emirates. Capnography being used to evaluate the patency of the patients' airway as well as a diagnostic indicator, supports the notion that capnography can be used at EMT-B level of care. Also, that it is currently being used appropriately at that level. Maintenance of patient airway patency is a big focus in EMS, and if EMT-Bs are using capnography as an objective measure to ensure patency, it is a very positive outcome in terms of patient care and safety (Vithalani, *et al.*, 2017).

5.4.4. Capnography use for patients with breathing difficulties by EMT-Bs in northern emirates (UAE).

Capnography is known to provide real-time, non-invasive monitoring of the patients ventilation status just as oximetry is recognised for oxygen saturation monitoring (Nagler and Krauss, 2009). While oximetry may have its limitations, in patient diagnostics when considering the categories of calibration assumptions, optical interferences and signal artifacts, the study focus was on capnography as an adjunctive POCT tool (Sinex, 1999). In the analysis of the utilization trend of capnography recorded in the historical data, 19.88% of the use was on patients recorded with breathing difficulty (Table 17). Exhaled CO_2 offers an accurate and reliable means of monitoring respiratory frequency. An elevated frequency of ventilation is a sensitive and a reasonably specific marker of respiratory insufficiency, while low frequency is related to respiratory depression (Siobal, 2016). The study analysis of the observed respiratory rate intervals with the use of capnography highlighted a trend of increased utilization in patients with low frequency ventilations (Table 32). In the analysis of capnography use correlated to the ventilation frequency categories between non-$ETCO_2$ and $ETCO_2$ monitored patients , found that the mean respiration rate was lower among $ETCO_2$ monitored patients (p-value of $4.5287735 \times 10^{-27}$). These results highlighted that capnography was used more in patients that were hypo-ventilating. The results (Table 32) also highlighted the increased use of capnography for patients with high-frequency ventilations when compared with patients with normal ventilation rates. Capnography use in hyperventilation or hyperventilation case scenarios shows appropriate use of the POCT tool. Hyperventilation is associated with low $ETCO_2$ values while hypoventilation may lead to increased $ETCO_2$ values, both of which, need to be managed to normal levels (35-45 mmHg) in most cases (AAST, 2018).

In a publication by Basis (2009), it was highlighted that first-responders and EMT-Bs operated advanced equipment such as Bag Mask Resuscitators, facial masks, oxygen equipment and monitors and they would be able to use portable $ETCO_2$ mainstream monitors with little training but, were not currently certified to do so; more than a decade later not much has changed. Bag Mask Ventilation is quite intense and requires concentration and skill to used effectively. Ventilation with a Bag Mask is technical and considered a two-person operation (Bucher and Cooper, 2018). Therefore, a single EMT-B assisting patient ventilation can be quite challenging and capnography can be used as an objective guide.

Of particular interest is the $ETCO_2$ use related to the patients' respiratory rates. The results reflect markedly increased utilization of $ETCO_2$ monitoring on patients that were either hypo-ventilating or hyperventilating, and this has highlights appropriateness of use (Table 32) (Helm, *et al.*, 2003; Culbreth and Gardenhire, 2020).

The relationship with Bag-Valve-Mask (BVM) and $ETCO_2$ use also showed high utilization with 49.34% usage on non-resuscitation patients and 54.01% on resuscitation patients (Table 34). This result has implications on guided patient support ventilation. Given the complexities of supporting ventilation in the sick or injured patient, capnography use is certainly advocated (Basis, 2009). It is encouraging that at EMT-B level of care, those that used capnography for respiratory pathology patients, used it more for the patients that needed it. This not only highlights the appropriate use, but also the diagnostic value associated with capnography use in managing patients with breathing associated pathology.

In another respiratory complication, using Asthma as an example, the patient in a mild to moderate condition, may be displaying signs of adequate blood oxygen saturation (SaO_2) however, ventilation may be quite labored and compromised. So, whilst the oxygenation may be maintained, the ventilation related to elimination of waste gas carbon-di-oxide (CO_2) may lead to a build-up over time thus eventually affecting the oxygen saturation as well. Oxygen loading onto hemoglobin is related to the CO_2 offloading (Wemplar, 2011). Capnography in Asthma patients has been shown to be of immense value. The typical ''Shark Fin" waveform with varying degrees of acuteness of the waveform angle (on Capnography) correlates to the severity of the bronchospasm and directly relates to airflow affecting CO_2 elimination as well as O_2 inflow and uptake (Howe, *et al.*, 2011). Therefore, capnography as a POCT tool can help determine the severity of the bronchospasm and note changes in relation to therapy provided with continuous monitoring. Researchers have shown capnography as a more reliable and specific tool to monitor the Asthma patient over the conventional Peak Flow Meter that was conventionally used (Howe, *et al.*, 2011). EMT-Bs in the current study also treat Asthma patients, and aside from the stethoscope, have `no other support technology or equipment to help assess airflow. With a tool like capnography, the possibility exists to not only measure severity but also measure the

response to treatment regimens (Nagler and Krauss, 2009; Wahlen, Bey and Wolke, 2003). In the study findings, Asthma case events, utilization of $ETCO_2$ monitoring featured at 27.68% of the utilization rates at EMT-B level of care (Table 33), this result was encouraging given the limited training and exposure that EMT-Bs were exposed to. These results also highlight that EMT-Bs that used capnography recognised its value in the management of asthmatic patients. This value also correlates with research identified potential uses of capnography in the pre-hospital setting (Wahlen, Bey and Wolke, 2003; Manifold, *et al.*, 2013).

5.4.5. Capnography use for the Head & Neck Injury patients by EMT-Bs in the northern emirates (UAE).

The National Association for Emergency Care Technicians (NAEMT) in collaboration with the American College of Surgeons (ACS) have published the Pre-Hospital Trauma Life Support (PHTLS) textbook, that is used extensively in the EMS setting for information and guidance on the care of trauma patients. NAEMT recognizes the use of $ETCO_2$ monitoring in the pre-hospital environment. Emphasis on regulating the patient respirations, to help moderate rising intra-cranial pressures in a head injured patient is made in Chapter 8: Head Trauma of their text. The use of $ETCO_2$ to control the rate of ventilation is advocated in correlation to the exhaled carbon dioxide parameters as a point-of-care/monitoring tool, in reducing the insult of a secondary injury to the brain (PHTLS 9th Edition). Frontline clinicians that treat majority of the head injured patients are EMT-Bs and access to capnography may have direct bearing on head injury patient care (Table 10). A head injury is a broad term that describes a vast array of injuries that occur to the scalp, skull, brain, and underlying tissue and blood vessels in the head. Head injuries are also commonly referred to as brain injury, or traumatic brain injury (TBI), depending on the extent of the head trauma. The trends analysed in the retrospective data, show that capnography was used for patients in the recorded of Head and Neck Injury category. The usage was 1.65%, accounting for the lowest overall usage. It must be acknowledged that all cases in this category, do not result in TBI or severe neurological deficit. Therefore, $ETCO_2$ may only be warranted for a portion of the 'Head & Neck category' case load which, remains undetermined. However, the Head & Neck Injury case load do provide an indication of prevalence as well as opportunity for $ETCO_2$ monitoring in the northern emirates. In fact, the actual numbers from the results show 1 944 events where $ETCO_2$ monitoring was conducted by EMT-Bs caring for Head and Neck injured patients (Table 10). The results of Head and Neck injury cases with the use of $ETCO_2$ monitoring also align to the regional demographics proportions (Section 4.2.1; Table 7; Table 9). EMT-Bs have to rely on the clinical skills and history to assess patients with head injuries. The prevention of secondary injury due to perfusion or oxygenation is the priority in the pre-hospital environment of these patients (Otten and Dorlac, 2017). By maintaining adequate oxygenation and ventilation,

the secondary insult may be limited. In the TBI patient, $ETCO_2$ values in the range of 35-40 mmHg should be maintained however, if there are signs of herniation, then an increased rate of ventilation while maintaining $ETCO_2$ values of 30-35 mmHg is recommended as a temporizing measure in attempt to reduce ICP (Pollak, 2020). The pathophysiology and role of capnography is further described in a latter part of this discussion, however, the highlight in this section draws attention to the skewed perception of low use of capnography in the Head & Neck injury patients by EMT-Bs. The use of capnography in 1 944 events in this category was significant and shows that EMT-Bs identify the value of capnography in this instance (Table 10).

5.4.6. Capnography use in Cardio-pulmonary Resuscitation (CPR) by EMT-Bs in the northern emirates (UAE).

In 2015 the ILCOR released an evidence paper supporting newer resuscitation guidelines based on extensive research with consensus from member organizations (Link, *et al*. 2015). Capnography when available was shown to optimize CPR quality and served as an indicator of ROSC, (Link, *et al*. 2015). In the UAE context, the frontline staff (by majority) do almost all the Cardio-pulmonary Resuscitations (CPR) and are the EMT-B group that also have access to $ETCO_2$ monitoring (Table 9, 14, 24). So, it makes sense for EMT-B staff to use capnography monitoring as a tool to optimize the resuscitation attempt.

In the historical data of EMT-B exposure in the northern emirates that was analysed, there were 774 opportunities for $ETCO_2$ use in resuscitation efforts that featured in the results (Table 9: Case Pathology Dataset). The establishment of $ETCO_2$ use trends in CPR was useful in tracking actual usage of 52.2% of the resuscitation cases in northern emirates (Table 23: Establishment of $ETCO_2$ use trend with CPR) . A Pearson chi-square test of independence was conducted to check for an association between BLS resuscitation (CPR only) and $ETCO_2$ utilization. The conclusion at 5% significance level is that there is an association between resuscitation and $ETCO_2$ utilization (p-value: 0), (Table 23). This highlights that the EMT-Bs used capnography as a POCT tool in more than half of all the resuscitations done in the northern emirates. This shows strong utilization levels and value of capnography perceived by EMT-Bs, seeing that they were not compelled to use the POCT tool, as it was not yet part of their current scope of practice (at the time), when it was only recently excluded (DOH Abu Dhabi, 2020). At the time of use, the supporting guidelines in the clinical practice guidelines (CGP 134) (Ayman; Cummins, 2019) was a base of reference.

In patients that had an advanced airway placed, and they were being resuscitated, the percentage utilization was 54.77% (Table 24) at a 5% significance level (p-value: 5.23×10^{-5}) highlighting the association of $ETCO_2$ use with CPR and a Supraglottic Airway. The confirmation of placement of the airway, together with CPR Quality and as a prognostic indicator, capnography

has been shown to have value (Basis, 2009). EMT-B historical trend use of capnography aligns with capnography use recommendations (Link, *et al.*, 2015).

When capnography use was analyzed against ROSC there was a 62.04% usage trend with $ETCO_2$ monitoring, and the association was confirmed with a Pearson chi-square test of independence that concluded at 5% significance level is that there is an association between ROSC occurrence and $ETCO_2$ utilization (p-value: 0.0398), (Table 25). The positive sign of resuscitation attempts linked to capnography use is encouraging. This also highlights that the POCT tool is being used effectively as intended. The finding, of the initial $ETCO_2$ values of less than 10 mmHg with CPR was recorded at 45.85% and 54.15% greater than 10 mmHg $ETCO_2$ which speaks to the quality of CPR with $ETCO_2$ use. A significant marker of interest (in resuscitation) is the $ETCO_2$ use with increasing $ETCO_2$ trends (with or without ROSC) which highlights that, in more than 1500 cases an escalation in $ETCO_2$ levels was observed. The increasing $ETCO_2$ value trend in (Table 29) shows greater than 90% increase rates of $ETCO_2$ levels on patients that experienced ROSC. Also, of note is that $ETCO_2$ monitoring was used on 62.04% of patients with ROSC (Table 30). $ETCO_2$ monitoring seems to correlate with positive outcomes, although there may be many variables that need to be considered. However, it could not be isolated that capnography use, (at EMT-B level) in resuscitation attempts have led to positive outcomes conclusively, but the strong correlation cannot be ignored. This bodes well for EMT-B use of capnography in resuscitation attempts and the ability to use such a POCT tool effectively in these events.

5.4.7. Capnography use in all other pathologies by EMT-Bs in the northern emirates (UAE)

There was also a broad band of **'**Other**'** cases where $ETCO_2$ monitoring may have had potential for use but weaker evidence in the literature, but significant none the less. Therefore, these were recorded as a group and accounted for a significant portion (34%) of the cases from the total 39 937 events. The utilization of $ETCO_2$ monitoring for this group was recorded at 4.52% which, seems much higher utilization than other groups where potential use is proven in the literature reviewed (Basis, 2009).

In the Psychological pathology category with a recorded 2016 events, utilization of $ETCO_2$ monitoring was at 2.09%. It must be noted that (an indication for $ETCO_2$ monitoring) in this group, hyperventilation syndrome could not be isolated (Gardner, 2003). The recommended treatment in these patients are to calm, reassure the patient and reduce ventilation rates (Derrick, Green and Wand, 2019). The days of the 'Brown Paper Bag' are long gone and should not be considered as a management option, as the consequences outweigh any perceived benefit (Callaham, 1997). Capnography may be a useful tool in monitoring the patient and determining levels of CO_2 in response to management strategies. Anxiolytics can be used in extreme cases however, they are not routinely recommended (Derrick, Green and Wand, 2019). At EMT-B level of practice, it can be confirmed that patients in this category were not given any sedation due to the administration

of narcotics being beyond their clinical scope. This also excludes the risk of respiratory depression secondary to sedation, that may be experienced at other higher clinical levels of practice.

General findings also included the measure of alert and spontaneous breathing patients with a GCS score of 15/15 that received $ETCO_2$ monitoring. The frequency was low at 1099 patients accounting for 3.27% of the events over the 12-month period. This highlights that $ETCO_2$ monitoring can be and is being used by EMT-Bs for monitoring of alert, spontaneous breathing patients (Table 31). Patient with critical illnesses including seizures, trauma, respiratory conditions such as pulmonary embolus or obstructive disease may benefit from capnography but more research in these fields have been advocated (Long, Koyfman and Vivirito, 2017).

In the UAE there is a large expatriate workforce contingent which, are predominantly male (Global Media Insight, 2020). In the Arab Country, Islamic (Shariah) Law prevails, and although the large expatriate community allows for a liberal lifestyle in the metropoles, the orthodox and less commercialized population areas of the northern emirates, sometimes are more rigid in terms of the Islamic culture. In some instance male care givers may not be allowed to assess or treat a female patient even in an emergency, due to males not being permitted to touch (non-familial) females according to Islamic culture (Bakhshizadeh, 2018). Therefore, an analysis in the historical trends was used to highlight the use of $ETCO_2$ across the gender line, to determine if there were any difference in the use of $ETCO_2$ (Table 36).

The gender analysis relation to $ETCO_2$ use, revealed that the difference between use of $ETCO_2$ in females versus males are not significantly different with a 4.96% and 5% use respectively. Therefore, gender bias and cultural factors anticipated could be negated (Table 36). While there may be no differences in the use of capnography across the gender-line, capnography may still be considered as a more conservative approach in assessing the opposite gender (to the clinician) for respiratory and ventilation assessments going forward (Johnson, Schweitzer and Ahrens, 2011).

5.4.8 Capnography ease of use and the time factor.

Some may argue that there was not enough time for capnography monitoring in a busy or demanding scene, or on the way to hospital. Therefore, the patient contact times were analyzed to determine if there was opportunity for capnography use in the historical trend analysis. The EMT-Bs patient contact time relative to $ETCO_2$ usage revealed that mean time spent with patient among non-$ETCO_2$ patients was 34.5 minutes and the mean time spent with patient among $ETCO_2$ patients was 37.87 minutes. It was concluded that mean time spent with patient was higher among $ETCO_2$ patients (p-value of 1.5708042×10^{-9}). The implications are that when there was enough time, that capnography was used on patients. Another view could be that the POCT tool

(capnography) took time to assemble and delayed patient transfer to hospital for handover. Without conclusive evidence one way or the other, this highlights the need for more in-depth research. However, the response to the ease of capnography use, and set-up results show that in fact $ETCO_2$ monitoring is fairly quick and easy to set-up and use (Table 56). By inference, the $ETCO_2$ may have been used on patients presenting poorly with greater contact time but.

Capnography set-up for use can be considered achievable as, it involves attaching a 'Sampling Line' ($ETCO_2$ sampling line) into a multi-functional monitor on one end, and the other to the patient adjunct. On the patient side, the Nasal Cannula $ETCO_2$ sampling unit or, an $ETCO_2$ side stream sampling adaptor can be used (Johnson, Schweitzer and Ahrens, 2011). The side stream adaptor is usually used with a Supraglottic Airway (i-Gel®) adjunct which, is used to maintain the airway in the obtunded patient, while the nasal cannula sampling unit is used with conscious patients (Johnson, Schweitzer and Ahrens, 2011). EMT-Bs are trained in using both these adjuncts in conjunction with capnography sampling set-up.

The results of the survey indicate that most of the respondents find the set-up for capnography use is always easy (49.8%), and usually easy (43.5%) respectively. This aligns with the notion, that the process is achievable at EMT-B level, and also may account for the training exposure that respondents received. The non-technical nature of the set-up may encourage use at an EMT-B level going forward and may be an important in consideration for the incorporation of capnography into the EMT-B scope of practice. It should be noted that the (set-up) delay implication for the use of capnography in the study has not been accurately analysed. However, the feedback is suggestive that it is unlikely to be a significant cause of delay.

Summary

Based on the historical trends, the uptake of capnography as a POCT tool has been generally low, with EMT-B staff using capnography only a small percentage of the caseload. The data highlights the potential for greater use capnography among the various pathologies where capnography has been shown to have value. Head injuries, respiratory pathologies, trauma, psychiatric, resuscitation and other cases of interest showed significant numbers and opportunity for $ETCO_2$ monitoring. This highlighted the potential exposure to case events where $ETCO_2$ monitoring could have been used to assist diagnostic skills by the EMT-Bs in the region. The incident mean exposure rate was at 62.63 per EMT-B, not considering any confounders that may have influenced the calculation. Yet, the actual uptake of $ETCO_2$ use per staff member was at 2.53, accounting for many missed opportunities. The mean time spent with patients was higher in patients receiving $ETCO_2$ monitoring, than those patients not being monitored with $ETCO_2$. This

was a concern and needs to be further interrogated despite confounders that may have affected these results.

The $ETCO_2$ monitoring use by the EMT-Bs was low (4.98%) overall. However, it must be qualified that given the geographical location, case numbers and staff participation there was evidence of maldistributed opportunity. Therefore, beside any training and education, support, guidelines or even resource availability, the opportunity to perform $ETCO_2$ monitoring by EMT-Bs was influenced by location but practiced non the less.

Capnography was used with airway control in patients where supraglottic airway devices were in-situ. Stethoscopes, may be of limited value in a noisy EMS environment, and capnography can and has been used by EMT-Bs to monitor patient breathing and also to asses patency of airway with the use of SGA's. in the absence of other confirmation tools, capnography has been accepted as an option and EMT-Bs are taking advantage of this as a POCT tool to confirm placement as well as monitoring of ventilation in such cases.

The 'head and neck injury' category showed the lowest usage of $ETCO_2$ monitoring (1.65%) but 1944 case events in this category with $ETCO_2$ use is still significant. Especially with TBI patients the use of capnography/capnometry has been advocated in EMS to help manage secondary injury, and some EMT-Bs have positively practiced such monitoring as evidence indicates.

The patient category with breathing difficulty enjoyed significantly higher utilization rates (19.88%) as with the resuscitation cases. Capnography was also found to be used on patients with Asthma at a rate of 27.68% at EMT-B level. Given that the patient assessment, status and response to treatment can be more objectively assessed using capnography, this is a very positive indication that EMT-Bs recognise the value of such a POCT tool in this category of patients.

Results also drew attention to the use of $ETCO_2$ in monitoring of patients that were considered hypo-ventilating (<10 bpm) or hyperventilating (>20bpm) which again highlights value of capnography in such circumstances and appropriate use of the tool at EMT-B level of care. Further, patients that needed support ventilations via a mechanical device such as the Bag-Valve Mask (BVM), were also managed with capnography use, at a rate of 54.01% for resuscitation cases and 49.34% for non-resuscitation cases. Given the subjectivity and difficulty in performing assisted ventilation, capnography is certainly a useful tool to have on hand, and EMT-Bs have shown use of capnography in supporting their diagnostic abilities.

For the resuscitation cases in particular, the capnography use was associated with increased utilization and positive outcomes. The $ETCO_2$ use trends in CPR highlighted actual usage of 52.2% of the resuscitation cases with positive outcomes using ROSC as a marker. This supports the use of capnography as a POCT tool at EMT-B level and highlights the potential for inclusion into EMT-B scope as a viable option in the UAE.

EMT-Bs operating in the Emirate of Sharjah area were exposed to a higher caseload with potential for capnography use and correlated to actual utilization with evidence of regional bias of EMT-B exposure rates. An unexpected finding of gender non-bias is good given the local religious and cultural setting, but this may also be due to the expatriate dominance in the study population. In $ETCO_2$ can be considered for objective patient monitoring and for a more conservative approach in patient assessment especially in the EMS environment. A positive finding is that, those that used capnography as a POCT tool, did use it appropriately. The overall epidemiological description of $ETCO_2$ application by EMT-Bs is that although utilization rate was low, there is ample opportunity for capnography use by frontline EMT-Bs, and that they show appreciation and value of the POCT tool with pathologies where the industry advocates capnography use. EMT-Bs in northern emirates of UAE, have shown via statistics that they can use capnography if the opportunity presents.

Objective 2: To document the Basic EMTs self-perception of the inclusion of $ETCO_2$ into their clinical scope.

5.5. What has been the EMT-Bs exposure and perceptions of $ETCO_2$/Capnography in support of their diagnostic abilities?

The study survey analysis overall highlights that the EMT-Bs in the cohort reflect, that the vast majority (81%) of the respondents have received some degree of exposure to $ETCO_2$ education. These results are concurrent with National Ambulance education programmes, that provide these exposures. The Basic Airway Course, Pre-Hospital Trauma Life Support (PHTLS) Course, Advanced Cardiac Life Support (ACLS) Course and Pediatric Advanced Life Support (PALS) Courses, all of which offer some level of information on $ETCO_2$/Capnography. Notably, not all EMT-Bs would be privy to ACLS and PALS Courses, as it would be considered beyond their scope of practice as EMT-Bs. However, due to EMT-Bs Nursing Degree background (Table 69), and privileging in extended scope practice (Ayman, 2019), they may be afforded access the ACLS and PALS Courses. Of particular significance, is that the majority (81%) of the EMT-Bs operating in the northern emirate, have admitted to some degree of exposure to $ETCO_2$/ capnography (Table 39).

5.5.1. Capnography application acknowledgement by EMT-Bs

With capnography being used as a POCT tool, a series of knowledge-based questions regarding uses of capnography ($ETCO_2$) in the prehospital setting was posed to the EMT-B group in the north. The commonly recognized applications of capnography enjoyed a better rating in industry

recognized uses, oppose to more recent applications such as for infectious diseases (incl. Covid-19) monitoring, in emerging research (Basis, 2009). The use of capnography in placement of the supra-glottic devices, support ventilation, managing the traumatic brain injury or in CPR cases are well acknowledged in current practice. (Kerslake and Kelly, 2017; Aminiahidashti, *et al.*, 2018 ; Kodali, 2013). Therefore, the EMT-B perceptions of capnography use in these categories was investigated.

As an indicator of Supra Glottic Airway (SGA) (i-Gel®) tube placement confirmation 57.4% confidently acknowledges capnography use with a further training; 21.5% deeming the POCT tool as a possibility (Table 62). With the use of capnography to guide support ventilation with a Bag Valve Mask (BVM), there was a confident 71.3%, followed by a 22% of the cohort that believed that capnography can be used to direct management (Table 63). The head injury category enjoyed a 63.7% perception that capnography can be used to guide treatment and another 30.1% deemed it possible (Table 42). The use of capnography in cardiopulmonary resuscitation (CPR) is well documented, and perceived as definite use by an overwhelming 86.3%. The majority of EMT-Bs acknowledged the clinical uses of capnography as a POCT tool in the pre-hospital setting and this is concurrent with literature reviews that support these views (Basis, 2009; Murphy, *et al.*, 2016; Donald and Paterson, 2006).

On the other hand, capnography uses in cases of alert, spontaneously breathing patients was less likely to be used (Table 67). Technically, every patient's respiratory rate and ventilation status could be assessed using capnography as a monitoring tool at EMT-B level of care. At the very least more objective respiratory rates can be observed in the field. However, the practicality together with economic and resource constraints need to be considered. Also, capnography not being formally adopted at an EMT-B scope of practice level, does not encourage its use from a regulatory perspective.

In the cases of infectious disease (which include Covid-19) patients, approximately 50% of the EMT-Bs were of the view that capnography can be used as a POCT tool. The study period of the historical data, (Phase 2) ranged from 01 March 2019 to 28 February 2020 which, was the pre-Covid-19 era in the middle east. Therefore, capnography utilization trends result, may not reflect current pandemic findings. However, the survey conducted late in December 2020, after the 1st wave of the pandemic, may have (rather speculatively) sensitized clinicians generally, to ventilation pathology associated with Covid-19. It is also noteworthy, that Covid-19 potential or confirmed cases annotations on patient records, were classified under the category of 'Infectious Patients.' Therefore, isolation of the Covid-19 case load alone, was difficult to determine. In recent publications, on the 'Happy Hypoxic' patients, of the Covid-19 variant, were shown to be relatively asymptomatic, aside from tachypnea that was a significant clue to the underlying pathology (Brouqui, *et al.*, 2021). These patients when assessed with POCT pulse oximetry tended to be hypoxic, with marked low oxygen saturation levels recorded (Brouqui, *et al.*, 2021).

Although tachypnea can be easily assessed in the quiet home environment in medical cases, the use of capnography can signify ventilation rates, ventilation volumes, bronchial status and respiratory acidosis status (Nagler and Krauss, 2009). Therefore, there may be a place for capnography monitoring in the Covid-19 patients as a POCT tool to guide assessment and care of these category of patients. Half of the cohort identify the potential use of capnography for the Covid-19 patients with certainty, and a further 37.1% acknowledge the possibility of capnography use for the category. Although, there has been no formal education initiatives dealing directly with capnography use on Covid-19 patients, most staff seem to be on the track, that there is potential for capnography use in this category of patients. The source of education in dealing with Covid-19 patients in particular, was limited in this study due to the only recent emergence of the particular infectious disease, and the need for greater research required on capnography use for the pathology in the EMS setting.

5.5.2. Diagnostics

This phase of the study analysis highlights the awareness of the EMT-B cohort, on the clinical application of capnography in the prehospital setting. The parameters that were evaluated, were the diagnostic interpretations (by means of $ETCO_2$ values and capnography traces) that were presented to the participants of the study. The intention was to determine if EMT-Bs were able to derive diagnostic value (if any) from common $ETCO_2$ values or capnography traces that could be observed when assessing a patient with the POCT tool, and the intended action taken given the values received.

5.5.2.1. Diagnostics: $ETCO_2$ as a quality indicator in CPR

In the case scenario presented to the participants of the study, a $ETCO_2$ Value of 18mmg/Hg was presented in a written and graphic form and was also associated with a CPR event. Considering the context, an $ETCO_2$ value of 18 mmHg observed in the presented scenario, was an indication of acceptable CPR quality (Sandroni, De Santis and D'Arrigo, 2018). Only about 40%, chose the correct answer. This result highlights a perceived gap in knowledge (in the remaining respondents) that may be addressed through training. At BLS level, a key priority in resuscitation efforts is to administer good quality CPR, as a basis of all resuscitation efforts(Link, *et al.*, 2015).

The majority of the cohort chose the option of 'Inadequate CPR being performed' which, implies that the value of $ETCO_2$ is not high enough to indicate 'Good Quality CPR.' Giving context to the scenario, in the real life setting and scenarios of resuscitation in the field there is evidence, that $ETCO_2$ monitoring is used in CPR cases with an External Compression Device like the LUCAS® Compressor (Gaxiola and Varon, 2008). If this is true, then the values of $ETCO_2$ observed, with

external compression devices that are much higher than 18 mmHg, may be considered inadequate compressions, given the higher values that staff have become accustom to, in the real-life setting (Gaxiola and Varon, 2008). This could be considered a confounder. However, this theory has not been tested and will need further investigation. In the interim the perceived gap in knowledge can be flagged as an opportunity for improvement.

5.5.2.2. Diagnostics: Capnography as an Indicator of ROSC

The CPR case scenario results (Table 48), reviews the diagnostic interpretation of a capnograph waveform, that may be realistically encountered, in a resuscitation attempt. In such an event the capnography may be an indicator of the Return of Spontaneous Circulation (ROSC) and the particular scenario presented (Sandroni, De Santis and D'Arrigo, 2018), tests the use and understanding of the capnography by the EMT-Bs where ROSC is achieved.

CPR may be attempted, if there is a perceived chance, that the patient may be resuscitated. In the pre-hospital setting, the detection of a palpable pulse (when no CPR is being performed at the time), is an indication that the patient's heart has started contracting (beating) on its own again. However, trying to detect ROSC is not always easy, and often subjective (Flesche, *et al.*, 1998). Also, the pulse as an indicator of ROSC may be transient or intermittent in the resuscitation attempt, or may not be detected at all due to the low volume or strength of the cardiac contraction (Chuck *et al.*, 2021). The more objective means of detecting the return of ROSC (out-of-hospital) can be with the use of capnography. A sudden escalation ''Spike'' of the capnography waveform and/or the $ETCO_2$ value may indicate ROSC (Lui, Poon and Tsui, 2016). This can be used as a reliable indicator, and alert the EMT-B of a change in the patients' status. Interestingly, 66.8% of the respondent have chosen the correct answer, in a scenario-based question with a sudden escalation in $ETCO_2$ values. This highlights the diagnostic ability of the EMT-Bs, noting the $ETCO_2$ escalation as an indicator of ROSC. While a further 19.9% chose the option of the escalation in $ETCO_2$ value as adequate CPR being performed. While the second option (adequate CPR) may not be entirely wrong, the ROSC option was the preferred response. Again, as per the argument presented previously (in 4.3.3 CPR Quality & $ETCO_2$), a confounding, exaggerated $ETCO_2$ value, may account for the 'Adequate CPR' choice (Gaxiola and Varon, 2008). The outcome does, however, highlight that majority of the respondent do have the knowledge and diagnostic ability to use capnography or $ETCO_2$ as an indicator of ROSC.

5.5.2.3. Diagnostics: Capnography use in TBI Patients

In head injury patients, that have suspected Traumatic Brain Injury (TBI), the contained volume of mass in the cranium of the skull, may be directly related to the pressure within that area. Therefore, any increase in 'Brain Mass' from edema or bleeding 'Blood Mass' or any other intrusion, or mass, can increase the pressure within the cranium, containing the brain (Grayson, 2016). The perfusion to the brain may be decreased as the pressure increases. The brain needing perfusion for the delivery of oxygen and nutrients to sustain its functioning, has a low tolerance for fluctuations in the needed essentials, resulting in altered levels of functioning (Kerslake and Kelly, 2017). The ultimate stage of reduced perfusion to the brain results in brain death. Therefore, the ability to limit the pressure increase, in the TBI patient is an important intervention in the pre-hospital setting (Chuck, *et al.*, 2021).

Capnography has been shown to play a role in managing the escalation of intracranial pressure, by guided ventilation support. The philosophy of increasing the patient ventilation rates, is thought to help to eliminate carbon-dioxide (CO_2), thereby inducing vasoconstriction and a reciprocal decrease in intracranial flow and thus bleeding (volume of mass). The rationale in-turn is to limit the escalation of intracranial pressure as a temporizing measure, until definitive management can be administered (Grayson, 2016). However, the decanting of too much CO_2 can cause vasoconstriction to the extent, that there is not enough perfusion to the brain and thus, is starved of oxygen, resulting in decreased perfusion and increased hypoxia with resultant edema and volume of mass exacerbating intercranial pressure resulting in secondary injury. Therefore, the regulation of $ETCO_2$ is an important factor in the management of TBI patients. Under normal circumstances, maintenance of $ETCO_2$ parameter values of 35-45 mmHg (while ventilating patients) are recommended, but as a last attempt to reduce ICP when treating TBI with patients signs of herniation, values of $ETCO_2$ in the lower range of 30-35 mmHg is recommended (Chuck, *et al.*, 2021; Pollak, 2020). Therefore, managing the rate of ventilation and subsequent $ETCO_2$ value maintenance, is important in managing TBI patients in the pre-hospital setting.

In the particular scenario-based question, the ventilation rate of 6 breaths per/min highlights hypoventilation (Otten and Dorlac, 2017). Support ventilation may be increased to 16-20 breaths per/min when there is evidence of herniation as a temporary intervention (Otten and Dorlac, 2017). Also, the $ETCO_2$ level supplied in the scenario, shows the $ETCO_2$ level being at the higher end of the scale which is not ideal. Therefore, increasing the rate of ventilation would be the recommended next action to be taken by the EMT-B in this scenario, and 63.1% of the respondents have chosen this option. This highlights the knowledge and diagnostic ability of EMT-Bs to manage TBI patients, with the use of POCT $ETCO_2$ as a diagnostic and management tool and is very relevant in this study. Respondents that did not relate to this diagnostic intervention, chose to rapidly transport the patient to the hospital as a next step. Given the clinical scenario, this would be a reasonable next action to follow. The option chosen by some of

the respondents 11.7% to decrease ventilation further (<6 breaths per/min) is of concern, in that it may constitute an unsafe action, and also highlights the gap in knowledge and diagnostic ability in this particular scenario. However, the majority of the cohort show appreciation for capnography role in managing TBI patients and recognize the diagnostic value.

5.5.2.4. Diagnostics: $ETCO_2$ capnography 'Shark-fin' waveform associated with a patient experiencing difficulty in breathing

In the UAE, breathing difficulty in the pre-hospital setting is a common symptom experienced by patients with respiratory pathology. This is substantiated by the data collected, in the 2019-2020 historical trend analysis prior, the Covid-19 era (Table 9). The historical data highlighted, 2424 patient records with 'Respiratory Difficulty.' In the particular case of asthma, that is characterized by pathophysiological broncho-constriction, mucous plugging and narrowed airways, that induce difficulty in breathing (Hearn, Kent and Jackson, 2020). The problem usually manifests in the exhalation phase of ventilation when chest and lung volumes decrease with the chest collapse and relaxing of the diaphragm into the chest cavity. Thus, with a decreased volume also exacerbating narrowed airways causing air trapping and a hyperinflated chest (LaPrad and Lutchen, 2008). Therefore, the prolonged expiration with difficulty in expressing air from the lung is a common feature in mild and moderate asthma conditions. In severe asthma both inspiration and expiration phases of breathing may be compromised and can lead to death if unabated.

Capnography has been shown to play a role in determining the severity of the asthmatic episode and also the response to treatment (Nagler and Krauss, 2009). Given the restricted airflow, there is retention of air in the chest, containing the increased level of carbon-dioxide (CO_2), perfused out from the pulmonary vascular circuit. The release of the CO_2 as it squeezes through the narrowed airways, forms a characteristic waveform in the capnography, that resembling a 'Shark Fin' shape oppose to the regular 'Squarish' shape of a normal capnograph. The greater the bronchoconstriction or narrowing of the airways with slower release of the CO_2, the greater the prominence of the 'Shark Fin' capnography waveform. Therefore, monitoring the shape of the capnograph can provide valuable information on the degree of airway restriction, and also the response to treatment with the dissipation of the Shark Fin feature towards a normal capnograph shape as the patient condition improves (Wemplar David A., 2011).

Using a stethoscope to detect wheezing and subtle changes can be difficult and often subjective. In cases of severe asthma with very limited or no air movement, little can be heard. The silent chest is an ominous sign in the asthma condition, and conversely in a clear chest, vesicular sounds can be barely heard in noisy environments. Therefore, the use of the stethoscope in these circumstances may be of limited value (Johnson, Schweitzer and Ahrens, 2011). Capnography, on

the other hand may be used as an objective measure of the patient respiratory status, and the response to treatment, by monitoring the $ETCO_2$ levels in laminar flow and the shape of the graphs produced by the vented air (Siobal, 2016). Even in some of the adverse conditions in the pre-hospital settings, $ETCO_2$ can be a valuable POCT tool, at the disposal of the EMT-Bs to support their diagnostic ability, in conjunction with existing tools.

Given the 'Shark Fin' capnograph presented in the survey scenario-based question, only 44.1% of the respondents chose the option of it signifying broncho-constriction. While a further 40.6% chose the option that the patient was hyperventilating which, again is not incorrect and may be an accepted response. The question was not specific to the shape depicted in the capnograph waveform, and any other clue cannot be omitted. While and increased respiratory rate does not always relate to difficulty in breathing, it may be a symptom of the pathology, associated with difficulty in breathing and may be accepted.

The responses, highlight that some respondents (44.1%), do have insight into the asthma pathophysiology, and see the diagnostic value of the capnography waveform as an indicator, in patients with difficulty of breathing. While it is not clear with the remaining respondents' reasons for the choice of other options. The gap in knowledge is identified as a potential for further exposure, education, and training on capnography role with respiratory patients. The use of $ETCO_2$/capnography from historical trends, has shown that crews at National Ambulance, used capnography the most with 'difficulty in breathing' pathologies (almost 20% of the cases). Table 30 – Utilization of $ETCO_2$ related to pathology trends, serves as reference. This result shows appreciation of the ($ETCO_2$) technology for use in patients with respiratory compromise.

Summary

The results of the second objective line of interrogation, highlight the positive value that the participants of the study have experienced with capnography use, at an EMT-B level of care with exceptions. The survey results revealed that 81% of the EMT-Bs that participated, acknowledged some degree of exposure to $ETCO_2$/capnography, with commonly recognized applications enjoying a better rating for use in the EMS setting. In the absence of other tools for confirmation of placement and/or determining patency of airway, capnography was considered as a possible option for this purpose. Only 54% of the participants acknowledged this role of capnography with the use of supraglottic airway placements. EMT-Bs can use SGAs, if qualified with the extended scope. $ETCO_2$ use to support ventilations with the BVM was acknowledged at 71.3% a and a further 22% can use $ETCO_2$ to direct medical management. There was a 63.7% perception among the EMT-Bs that Head injury patients can 'Definitely' benefit from $ETCO_2$ use, with a further 30.1% deeming it a possibility. With CPR cases 86.3% indicated that capnography can be used with

benefit in resuscitation attempts. However, with spontaneous breathing patients' capnography was less likely to be used, given that it was not a current requirement at EMT-B level of care but remains an option. The EMT-B group perceptions on Infectious disease patients and the possible use of capnography as a diagnostic tool stood at 50%. Current indications for use with Covid-19 patients lacked evidence, and no view was adopted for capnography use in these cases.

In terms of the diagnostic inferences that EMT-Bs derived from scenario-based question posed in the survey, the following results were observed. Only 40% of the respondents chose the correct answer, that the $ETCO_2$ value observed in graphic representation was an indication of adequate quality of CPR being performed in the resuscitation case. This highlights a gap in knowledge that needs to be addressed. An alternative view is that, given the local norm with the use of external compressor devices used in EMS, the $ETCO_2$ value in such circumstances would be considered low as values above 20 mmHg of $ETCO_2$ is not un-common with these devices being routinely used by the EMT-Bs involved in the study. Therefore, the result may be confounded and requires further investigation. In the ROSC diagnostic scenario 66.8% of the respondents chose the correct answer, identifying the sudden escalation of the $ETCO_2$ value and morphology change as ROSC indication. The head injury scenario with indication of hypoventilation on the capnography trace was recognised and treated appropriately by 63.1% of the EMT-B respondents. However, a worrying 11.7% of the respondents chose to decrease respiration rate further which, highlights a gap in knowledge and also has patient safety implications that will need to be addressed if capnography inclusion into the scope is to be considered.

With the respiratory diagnostics scenario presenting with the typical 'shark fin' waveform characteristic of bronchospasm, 40.1% chose the correct answer identifying the possible pathology. Some respondents calculated the rate and identified the trace as hyperventilation but was not the anticipated response given the shape of the waveforms. This again highlights a gap in knowledge and opportunity for education and training to address as an option.

Overall the respondents did not fare well in the diagnostics section of the survey. The gaps in knowledge point toward the need for more research and greater exposure on the current and emerging uses of POCT capnography. The evidence indicates that, with the required support, EMT-Bs do show potential to take on capnography with training and support as part of their enhancement going forward. The majority of EMT-Bs in the northern emirates (UAE) show diagnostic ability and acknowledgement of capnography as a POCT tool of value in the pre-hospital setting.

Objective 3: To provide context to task shifting in settings of greater need than resources availability, while exploring opportunity cost versus risk benefit

5.6. Context to task shifting with opportunities and risk exposure

5.6.1 Task Shifting

The Basic Life Support (EMT-B) clinicians who, are junior clinical staff that make up the majority of the frontline work-force in the northern emirates of UAE (Table 68). The EMT-Bs' are formally considered as part of 'Ambulance Worker' category by International Standards (Categories 2240 & 3258) International Standard Classification of Occupations (ISCO-08).

The EMT-B's have a very generalized and wide scope of practice encompassing a variety of emergency care conditions with basic knowledge but guided by protocols for safe practice at operational levels. Limited on-site clinical support for the EMT-B's does not preclude them from having to make critical clinical decisions, in an emergency considering their setting and resources available.

Capnography, generally falls within the scope of Advanced Life Support EMTs (EMT-A) and is not normally associated with basic levels of care (DOH Abu Dhabi, 2020). However, the EMT-Bs need all the support they can get in an austere environment and the absence of higher clinical on-site support. Therefore, any POCT tool that can support EMT-B diagnostics and management would be an advantage (Basis, 2009). Capnography can provide objective information to EMT-B technicians given the recent advances in technology (Donald and Paterson, 2006; Basis, 2009). People around the world are also more informed about medical care, and are demanding greater quality in health care they receive, together with accountability (Williams, 2000). Therefore, health workers need to continuously develop and change their practice behaviour, to keep abreast of developments in the health care (Williams, 2000).

However, behaviour change that is sustained, is difficult to achieve, and often involves a variety of strategies. Without going into multitude of complexities that play a role in behaviour change, the 'Strategies for promoting behaviour change,' may be significant in assisting health workers in modifying and improving their skills. The World Health Organization (WHO) in a discussion paper provided some context and guidance, to behaviour change strategies for health care providers in improving skills and guides this discussion (Williams, 2000) and still has relevance.

Behaviour changes may be accomplished in a series of stages, as described by Prochaska (1988) in his Trans-theoretical Model (TTM). These stages are described as pre-contemplative, contemplative, decision, action and maintenance stages (Wayne W. LaMorte, 2019). In the pre-

contemplative stage, the person or health worker may be unaware of the change requirement, they may not see the problem nor want to take any action (Williams, 2000). In terms of POCT capnography, EMTs may not be aware of the technology or why it may be important to them in managing patients or improving quality of care. In the contemplative phase, the EMTs may become aware of the emerging technology or, they may recognize problems associated with current practices. They may also consider the pros and cons of options available to them for change, leading up to the 'decision stage'. Also recognised as the Determination stage, where an active decision is made, and steps are taken toward making a change. In the current study context, an example may be that, if the EMTs decided that they want to learn more about capnography to improve the quality of cardio-pulmonary resuscitation (CPR) and start learning more about the technology as an initial step. In the Action Stage, the EMT may be trained and introduced to, or using capnography as a POCT tool in patient care. And when he/she gets comfortable with its use and experiences the benefits in managing patients with the use of capnography, the use is likely to be sustained. Then the 'Maintenance Phase' is reached in summary (Wayne W. LaMorte, 2019). Maintenance is difficult, and a conducive environment with reinforcements can help to sustain changes (Williams, 2000). The simplicity of the analogy does not do justice to the other variables that may influence the development through the stages, nor does it reflect the sustainability of the behaviour change.

The Multiple environments that influence practitioner behaviour are as follows (Williams, 2000):

a. The immediate environment, with patient interactions and work colleagues in the same EMS System. They may all be embarking on change with the advent of newer technology, so the individual may be supported. Positive outcomes in patient management may also influence the practitioners, while poor outcomes may have the opposite effect.
b. Personal environment, personal preference, and values or other factors, also affect the practitioners' attitude toward a change.
c. Educational environment, where dedicated education and training may gear the practitioner up for practice. Also, education may provide greater confidence, and/or positive experiences, that may influence the uptake of a new skill such as POCT capnography. Educated staff that are confident with news skills and have positive experience can also serve as advocates of change.
d. Professional environments, such as the Regulating Health Authorities that may recognise the improvement or enhanced skill, as an extended scope practice that may be accepted. Licensing and credentialling systems will play an important role in the enhancement of any clinical practice. Also, regulation by the organization may influence a matter like capnography use if it was promulgated.
e. Community environment may influence the practitioner in terms of how he/she or the profession is perceived, among the medical community. In the current context if National

Ambulance is perceived as a leader in the field of EMS and they are among the first to lead changes, in the adoption of new technology to better manage patients. Staff may be encouraged to take up challenges as proud members of the organization.

f. Administrative environment, that regulates and governs the provider behaviour also bears significance. If the Policy, Procedures or Protocols calls for capnography use in specific clinical scenarios, the staff would be guided be these and supported change would be inevitable.
g. Economic environment is a huge influence. If the resources were made available for POCT capnography use in ambulances, the staff would be more encouraged to use these resources supporting the uptake of newer technology and enhanced quality of services.

Other factors that may promote behaviour change are predisposing factors like the access to education material, attendance of conferences or research and development initiatives etc. Enabling strategies such as increased practice, clearly defined guidelines, care maps and practice algorithms, reminders and computer based clinical decision supports also play a vital role in modifying behaviour or enhancing practice levels (Williams, 2000). At National Ambulance an example of the Revised Trauma Scoring System that is built into the Patient Care Record, that when populated, automatically calculates the triage of the patient, and alerts the EMT to the severity of the patient condition (Ayman; Cummins, 2019). If capnography prompts were included in a similar system, then, these could serve as reminders for clinical staff to use the technology and enhance patient care quality.

Audit and feedback also speak to quality improvement. In the survey conducted among the EMT-B clinical staff operating in the northern emirates, more than 50% of the clinical staff reported that they never received clinical audit feedback (Table 58) related to $ETCO_2$. From a clinical management perspective, the use of capnography although encouraged, has not been enforced at an EMT-B level of practice at National Ambulance (Ayman; Cummins, 2019). In recent years with the advocacy of capnography in resuscitation and in head injury patients, there was heightened expectation from bodies such as the American Heart Association (AHA) and the National Regulatory Emergency Medical Technicians (NREMT) organizations respectively, to use capnography by way of recommended clinical management practice (Link, *et al.*, 2015). However, the clinical level of staff that was targeted was not specified. Therefore, capnography did not fall into the audit criteria list. However, going forward it may be something to be considered in the clinical quality measurement if adopted by management for EMT-B use.

5.6.2. Exposure (Education & Training)

The baseline qualifications captured in the demographic detail (Table 69), highlights that majority of the respondents have EMT-B (94%), Nursing Degrees (93.2%), PHTLS (89%) and Basic Airway Course (86.1%) qualifications. The implications are, that this is a well-qualified group and together with their experience levels (Table 66), coping with capnography implementation is a possibility given some of the safety concerns. Also, with the qualifications that the EMT-B majority have in hand, highlights that there would have been some degree of capnography exposure on each of the qualifications attained.

The results of $ETCO_2$ related training categories that afforded EMT-Bs exposure (Table 83), highlight that short-courses, at National Ambulance offered the most exposure to capnography by 67.6%, a view shared by more than two-thirds of the respondents. The primary qualifications, at the respondent's home country, before coming to the UAE also offered some exposure to capnography was the view of 33.5% of the respondents. In the resource rich, progressive middle-eastern setting, exposure and training to enhance quality of care and the implementation of leading-edge technology is prioritised.

The particular short courses at National Ambulance, that exposed EMT-Bs to capnography is tabulated in Table 71 (order of maximum to minimum exposure). Short courses EMT-B (67.6%), Basic Airway (58.7%) and PHTLS (37.4%) have shown to have offered maximum exposure to the cohort. While these courses offered some exposure, and most staff are already qualified with these courses, the need for refreshers on these courses may be warranted given the further need for training and education highlighted in the survey (Table 61, Table 62 and Table 63). Other options may include that implementation of a tailor-made programme with structured learning on capnography technology, use and interpretation for diagnostic enhancement at EMT-B level.

From the results of the survey question on the EMT-Bs perception of exposure to training and education of capnography, the majority by 59.1%, do admit exposure. The degree of training and education is further delved into in section 4.3.26. Response to survey question: On which category of training was there $ETCO_2$ exposure. However, it must be noted at this stage, that exposure was intentionally vague, as a formal programme for the use of capnography as a POCT tool, is yet to be established at National Ambulance. Although, there are many courses, that contain elements of capnography in their composition, and may have afforded respondents some degree of exposure at EMT-B level of care a formal programme has not been tailored for EMT-B clinical scope needs.

National Ambulance inducted new recruits through a myriad of refresher and short courses to meet the needs of operations within the company. A stringent induction programme aimed to standardized clinical practice for recruits arriving from various parts of the world with differing

experiences and education standards (Ayman; Cummins, 2019). As part of the EMT-B induction, staff were exposed to an EMT-B refresher programme, supplemented by a Basic Life Support (BLS), Pre-hospital Trauma Life Support Course (PHTLS), Basic Airway Course among many other short-courses. Worthy of note, is that the Basic Airway and PHTLS courses both contained elements of capnography training in the courses (Quinlan, 2015). For the limited few, that had exposure to Advanced Cardiac Life Support (ACLS) and Pediatric Advanced Life Support courses (PALS) there were added capnography exposure. Post induction, National Ambulances tailored 'Resuscitation' courses were also rolled-out, to EMT-Bs in the north, as part of an extended scope of practice capacity building effort. This may have offered some limited exposure to capnography in resuscitation efforts.

The results of the survey question related to the EMT-Bs perception of value of the $ETCO_2$, training and education courses, highlight that close onto half (49.6%) of the respondents found the courses to be useful in contribution to it being used as a diagnostic tool while, a further 24.8% found it extremely useful, in contributing to capnography being used as a diagnostic tool. Therefore, in combination 74.4% of the respondents found good value, in the training and education efforts, in supporting capnography use as a diagnostic tool.

The survey question relating to the perception of the adequacy of training, to cope with capnography, was intended to determine the level of preparedness of the EMT-Bs, to take on the task of capnography. The results highlight, that only a small minority (2.8%) of the respondents, feel confident in taking on the task of without further training. This points to the need for further training and development in the use of capnography. A following 39.5% of the staff feel they can cope adequately. While the majority (44,7%) can cope most times but require further training and support. Together, with the remaining 13% of respondents, there is a clear indication for the need of further training and support. These finding were concurrent with finding of another study also dealing with capnography use but at Advanced Life Support (ALS) level and a different focus (capnography use in confirmation of endo-tracheal tube placement) that does not apply to current study population. One of the outcomes of the study also recognized further training as a need, despite the study being conducted on a totally different clinical level and operational setting (Wylie, Welzel and Hodkinson, 2019).

The results of the survey question on the need for more (capnography) education and training, highlight the pathology specific needs (Table 75). It is evident that the perceived needs are that more training across all pathology categories (related to capnography) are required. Trauma and medical cases as well as CPR events rated the highest needs. Given the respiratory pathology associated with Covid-19, as an emerging trends of capnography use, will also require further training and is reliant on emerging research.

The survey response of the factors that would encourage future use of capnography are significant in this study (Table 76). This particular feedback does not necessarily identify gaps, but more so, the respondents' perception of what they need at the particular point in time, to encourage future use of capnography. Education and training were perceived as the biggest need (80.1%). The listed factors will need to be interrogated to a greater extent, for action to meet the needs of the EMT-Bs, if capnography will be adopted into their scope of practice. With the evolution of medicine and the rapid spurt in technological advancements, there is always going to be a need for the introduction of newer technology (Klaus Schwab, 2016). Training and support to adapt to keep up, may be the cornerstones of progress in emergency medical care.

5.6.3. What are opportunities uncovered from the study (benefits) that may encourage $ETCO_2$ use in future?

5.6.3.1. Opportunity for capnography future use in management of Covid-19 Patients

The study period of the historical data, (Phase 2) ranged from 01 March 2019 to 28 February 2020 which, was the pre-Covid-19 era in the middle east. Therefore, capnography utilization trends result, may not reflect current pandemic findings. However, the survey conducted late in December 2020, after the 1st wave of the pandemic in the UAE, may have sensitized clinicians generally, to the respiratory pathologies associated with Covid-19. For the purposes of the study, it is also worthy of note, that Covid-19 potential or confirmed cases, were classified under the category of 'Infectious Patients.' Therefore, isolation of the Covid-19 case load alone, was difficult to determine.

In recent publications, on the 'Happy Hypoxic' patients, of the Covid-19 variant, were shown to be relatively asymptomatic, aside from tachypnea that was a significant clue to the underlying pathology (Brouqui, *et al.*, 2021). The use of capnography can signify ventilation rates, ventilation volumes, bronchial status and respiratory acidosis status (Nagler and Krauss, 2009). Therefore, there may be a place for capnography monitoring in the Covid-19 patients as a POCT tool to guide assessment and care of these category of patients.

Half of the cohort identify the potential use of capnography for the Covid-19 patients with certainty, and a further 37.1% acknowledge the 'possibility' of capnography use for the category (Table 46). The source of education, on the matter of dealing with Covid-19 patients, was limited in this study. However, there is opportunity for Capnography as POCT tool use in Covid-19 patients but, this is yet to be explored especially in the pre-hospital sector.

5.6.3.2. The Opportunity to improve Guidelines

The Patient Care Protocols (CGP 134), was made into policy by National Ambulance, and was used to guide clinical practice in the service(Ayman,; Cummins, 2019). The results of the survey highlight that about half the respondents (49.6%) found the guidelines 'Mostly adequate' while another 21.7% responded to the guidelines being totally adequate (Table 55). The remaining respondents were unsure (20.9%) with a minority showing that it was inadequate. Despite several revisions of the guidelines, there may still be room for further revision in capnography use.

5.6.3.3. The Opportunity of Resource availability

A survey question, related to tools availability of for capnography use in the current work setting (Table 57) was posed to the cohort. Just above 70% of the respondents, report that the tools required for $ETCO_2$ monitoring are always or usually available. The result highlight that majority of the time, the tools required for capnography, like the $ETCO_2$ monitoring and interpreting device (LP 15), $ETCO_2$ sampling-line with adapters, oxygen nasal canulae with CO2 sampling options are available to EMT-Bs in the frontline. This is important in trying to understand, why staff may, or may not be using the POCT tool. A statistical correlation was done to interrogate the relationship between the historical trends in 'Capnography Use' and the 'Availability of Capnography Tools' results in the survey. The analysis revealed a statistically significant relationship between availability of tools and $ETCO_2$ utilisation (pp-value: 7.4×10−97.4×10−9). The main finding was that the 'Always' group in terms of 'availability of capnography tools,' was slightly more likely than the 'Usually' or 'Occasionally' groups to utilise $ETCO_2$. The respondents' that reported that the tools may 'occasionally' be available, was not further interrogated. However, addressing the gaps of accessibility of the tools will go a long way in the encouragement of capnography use going forward. As a confounding matter not included in the study, there is an allocation of two (2) $ETCO_2$ sampling line adaptors and two (2) Nasal canulae sample units only, allocated to the front-line operational units, in their response kits. These limitations may also have impact on utilization trends and can be reviewed if capnography use is to be encouraged.

5.6.3.4. The Opportunity of capnography in the management of alert, spontaneous breathing patients

Capnography was mainly associated with the placement and monitoring of endo-tracheal tubes in sedated, or obtunded patients. However, in emerging trends of capnography use, even the fully conscious patients may benefit from these POCT strategies (Wahlen, Bey and Wolke, 2003).

A question was posed to the cohort, on the perception of $ETCO_2$ possible use, for the monitoring of fully alert spontaneous breathing patients (Table 45). The findings were that only 44% of the respondents selected the option that $ETCO_2$ can be used for fully alert (GCS 15/15) spontaneously breathing patients. A further 21.5% supported the possibility of its ($ETCO_2$) use, in the selected patient category. Although, in combination it could be taken as the majority. This also highlights the gap in knowledge, in dealing with fully conscious, patient monitoring and ventilation status. Even without the presence of pathology, just monitoring ventilations in the pre-hospital adverse conditions (poor lighting, noise, confined space, vehicle movement, etc.), may be difficulty in assessing patient ventilation accurately. The $ETCO_2$/capnography POCT can be a useful tool to monitor ventilation in the alert, conscious patients that include pediatric patients (Summit, *et al.*, 2019).

Another opportunity specific to the UAE context, may be the use of capnography in the management of opposite sex patients (EMT-B to patient gender difference). In the United Arab Emirates (UAE) there is a large expatriate workforce contingent which, are predominantly male (Global Media Insight, 2020). In the Arab Country the Islamic Law prevails, and although the large expatriate community allows for a liberal lifestyle in the urban area, the orthodox less commercialized areas of the northern emirates sometimes are more rigid in terms of the Islamic culture. In some instance male care givers may not be allowed, to assess or treat a female patient in an emergency, due to males not being permitted to touch (non-familial) females according to Islamic culture. Therefore, an analysis in the historical trends was used to highlight the use of $ETCO_2$ across the gender line, to determine if there were any difference in the use of $ETCO_2$ (Table 36). A Pearson chi-square test of independence was conducted to check for an association between gender and $ETCO_2$ utilization. The conclusion at the 5% significance level is that there is not an association between gender and $ETCO_2$ utilization (p-value: 0.906). Given the low utilization of capnography in the pre-hospital setting, especially in the 'alert and spontaneous breathing patient group,' it was not surprising that no significant difference in Capnography use across the gender line was evidence. However, using capnography as a POCT tool, may be an alternative to having to physically assess female patients using a stethoscope or exposing the patient to observe ventilations in the UAE setting. Also, capnography can provide more objective information on patients respiratory and other statuses as research highlights (Donald and Paterson, 2006).

5.6.3.5. The opportunity for safe use of capnography

An analysis was done on the 'Exposure to $ETCO_2$ Training vs. Safety perception of coping with $ETCO_2$ technology at EMT-B level' was conducted (Correlation 2.13). The results highlighted that as per the respondents' experiences, that the training exposure they received (however limited)

was related to the safety perception of coping with capnography at an EMT-B level. A Fisher's Exact Test of Independence verified that (p-value: 0.00792) the relationship is statistically significant at a 5% confidence level. Therefore, the opportunity of enabling EMT-Bs to use of capnography safely does exist. The implications are that capnography education and training in safe use of capnography by EMT-Bs is a real possibility.

5.6.4. Risk Exposure

Having interrogated the education and training exposure of capnography experienced by the EMT-Bs alone, provided some value in terms of coping and safety.

To delve into the risks, associated with capnography being initiated at a basic level of care, the EMT-Bs perceptions of training efficacy in coping with capnography was explored. A correlation between the sets of data retrieved 'Have you received any exposure to education on $ETCO_2$ / Capnography?' correlated to 'Are you adequately trained to cope with capnography ($ETCO_2$) technology at BLS Level' was conducted. A Fishers Exact Test of Independence (pp-value: 0.00792) proved that the relationship is statistically significant at 5% level of confidence. Exposure was related to perception of adequate education. This highlights that the afforded exposure to $ETCO_2$ education and the confidence of the EMT-Bs in taking up $ETCO_2$ technology at Basic Life Support (BLS) level are related. The implications being that, the greater the educational input and exposure the better the ability to cope with capnography at a basic level of care, thereby mitigating against risks.

Risk may also be limited through policies and clinical guidelines. At National Ambulance, there are approved clinical care guidelines (GCP 134), that direct clinical management in the service. In these guidelines, specific mention of capnography is made in the treatment of Respiratory, Head Injury and other scenarios that encourage the use of capnography (Ayman; Cummins, 2019). The question in the survey was intended to evaluate if the EMT-Bs were aware of these guidelines. The results show that 67.7% are aware of the formal documents that encourages capnography use and a further 19.7% of the EMT-B respondents, think that 'maybe' there are documents, that encourage capnography use. The gap in awareness is highlighted. Other results of the survey (Table 55) highlight that about half the respondents (49.6%) found the guidelines 'Mostly adequate' while another 21.7% responded to the guidelines being 'Totally Adequate.' The remaining respondents were unsure (20.9%) with a minority showing that it was inadequate. Despite several revisions of the guidelines, there may still be room for further revision in capnography use. However, the protocol lead guided practice makes for safer patient care and clearer EMT-B clinical care guidelines mitigating risk.

It is also noted that use of capnography has not been enforced or fully implemented at EMT-B level, and remains a POCT tool to be used at the discretion of the Medical Director (Ayman, 2019). This is of value in the study, as it not only highlights the level of awareness and exposure but, also the potential for effective use by EMT-Bs if they are privileged to use the POCT tool. These have safety implications and reduce risk.

From a clinical management perspective, the use of capnography although encouraged, has not been endorsed at an EMT-B scope of practice at National Ambulance (Ayman; Cummins, 2019). In recent years with the advocacy of capnography in resuscitation and in head injury (TBI) patients, there was heightened expectation from bodies such as the American Heart Association (AHA) and the National Regulatory Emergency Medical Technicians (NREMT) organizations respectively, to use capnography by way of recommended clinical management practice (Link, *et al.*, 2015). However, the clinical level of staff that was targeted was not specified. Therefore, capnography did not fall into the local (NA) audit criteria list. However, going forward it may be something to be considered in the clinical quality measurement if adopted by management for EMT-B use.

The perception of pressure, experienced by the respondents for using capnography (Table 60), talks to two aspects. The formal implementation of $ETCO_2$ use by EMT-Bs, and the safety issue, if a recommended process of implementation has not been adhered to. Given these parameters, it seems that a small population of respondents feel pressured to use capnography in proportions of 14.6% and 1.2%. This may be considered a safety concern, if a formal implementation process, with adequate education, training, policy and guidelines were not in place. Most of the respondents experienced 'little' or 'no pressure' in proportions of 42.3% and 41.9% respectively. The safety of capnography use must be considered especially with planning to introduce capnography to Basic level practice.

Lastly, on the safety aspect. The survey question related to capnography sampling, and use of the information to further manage the patient, was intended to delve into the safety side of capnography use (Table 61). In that, if respondents were observing $ETCO_2$ values and/or capnography traces but, didn't know how to deal with the acquired information, it could be diagnostic capability and/or safety related. One respondent 'Always' does not deal with the capnography information acquired.' This may be due to a knowledge gap, or the capnography values retrieved that did not warrant alternate management. A further 19 (7.5%) respondents, 'often' encounter a similar situation where, the information gained, was not used to direct management of their patients. And 28% of the respondents were 'occasionally' faced with a situation where they did not use the $ETCO_2$ value/capnography, to further direct treatment of their patients. This may highlight a gap in diagnostic ability, or it may be that the values monitored were acceptable for the patient condition, or that $ETCO_2$ was used for merely monitoring of respiratory rates. Even though the findings of the analysis were inconclusive, it is important to

note that by not using the $ETCO_2$ information acquired (as if no $ETCO_2$ was available), no further harm was caused. The overall positive perceptions (Phase 3) on capnography value and use, in correlation to usage trends evidenced (Phase 2) that highlighted appropriate and safe use of capnography at EMT-B level of care has positive implication for an EMT-B level of practice inclusion.

Summary

In recent developments and Covid-19 crises more research is required regarding the use of $ETCO_2$ in the general, but also in EMS. In any new intervention or scope expansion, risk is anticipated. To reduce risk at EMT-B level of care there is opportunity to refine protocols, policy and procedure guidelines to enhance safer practice. A structured approach, with continuous monitoring and oversight through audits can support behaviour change in terms of crew adopting new technology or scope inclusion and can also support sustainability of new interventions. To practice, one would need resources, and these were found to be largely available even at EMT-B level in the frontline. However, a 100% coverage was not yet attained. Beside the resources, education and training exposure remain the cornerstone for effective and safe practice. Going forward, greater use of capnography in non-intubated, non-ventilated patients could be encouraged, even if it just for monitoring purposes. There are many opportunities for capnography to be included at an EMT-B level of practice, while the risks may be mitigated.

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Chapter 6 - Conclusions and Recommendations

6.1. Conclusion

The study set-out to address the gaps in the knowledge, of how the diagnostic capability of EMT-Bs may be altered by the enhancement of POCT capnography, as well as the perceived value of the diagnostic tool given the exposure.

The second phase of the study provided a clearer perspective of the prevalence of the pathologies in the northern emirates of the UAE and highlighted opportunities for capnography use by the EMT-B cohort. The subsequent investigation highlighted the actual usage trends of $ETCO_2$ by the study cohort, and although utilization was low for most scenarios, there was positive signs of appropriate and effective use of $ETCO_2$ in the pathologies where $ETCO_2$ use was shown to be of diagnostic value in literature reviews.

In the retrospective data collected from Patient Care Records (PCRs), the high caseloads observed in the Sharjah Emirate compared to other emirates drew attention to the maldistributed caseload and the geographical bias of capnography exposure to cases (p-value: 1.17x10-12). $ETCO_2$ utilisation by EMT-Bs caring for Head and neck injuries showed 1.65% use, Breathing difficulty: 19.88% use, Trauma/Assault cases: 2.73% use, Mental/Emotional and Psychological cases: 2.09% use, and the other case categories were at 4.52% utilisation. Although, low levels of usage were recorded, those that did use capnography, used it as indicated. Trends in monitoring of patient respiration rates beyond normal parameters (10-20 breaths per minute) using capnography highlight appropriateness of use; also seen with assessments of Asthma patients (27.68%, n = 49), assisted ventilation (49.34%, n = 113) in resuscitation cases and in non-resuscitation cases (3.78%, n = 1470). Ventilation assessments are subjective, even more so with support ventilation and capnography can be seen to play a positive role in guiding ventilation in assessment and support. In the pre-hospital EMS setting with adverse environmental conditions and the nature of work, capnography can be of value to EMT-Bs in the frontline.

The mean shock index was lower among $ETCO_2$ patients (p-value: 2.1115793×10-98), although $ETCO_2$ can be used as an indicator of shock, at EMT-B level of care may be complex given the context of interpreting the values in a multi-trauma patient. In any event EMT-Bs at National Ambulance have alternate tools in identifying shock and the role $ETCO_2$ use in detecting shock may be downplayed, as a diagnostic tool in these cases.

In the resuscitation cases, the use of $ETCO_2$ was significantly higher than other categories and also aligned to positive outcomes proven by other research (ILCOR), and this was positive and bodes well for capnography inclusion into the EMT-B scope of practice. $ETCO_2$ was used on 52.2% of the resuscitation cases and among those CPR cases that had airway adjuncts in-situ, 54.77% of them were monitored with $ETCO_2$ (p-value: 5.23×10-5). EMT-Bs do see value of capnography in

confirming placement in the airways of resuscitation patients, as well as using capnography as a quality measure in resuscitation. This was also reaffirmed in the findings of CPR cases where, 62.04% ROSC was observed with $ETCO_2$ use (p-value: 0.0398). The 0-10 mmHg category of $ETCO_2$ has the greatest escalation trend in more than 1500 cases. In resuscitation attempts, $ETCO_2$ values of less than 10 mmHg is associated with decreased survival rates. The escalation of $ETCO_2$ values in resuscitation attempts points to the increased quality of cardiac compressions, especially with initial values below 10 mmHg that escalates to above 10 mmHg. Beside capnography use in resuscitation cases, the overall results highlight the EMT-Bs ability to use the POCT $ETCO_2$ tool appropriately albeit with low utilization rates in other cases.

From the education and training perspective, majority of the EMT-Bs that are in the frontline operations 94.2% (n = 438) of them allocated in the northern emirates, 81% (n = 221) of EMT-Bs acknowledged receiving some degree of exposure to $ETCO_2$/capnography education. Although operating at an EMT-B level, 94% (n = 258) these staff have Nursing Degrees and with all having EMT-B qualifications. There was limited bias in capnography use, between the EMT-Bs having a Nursing Degree qualification or not. There was not a statistically significant relationship between EMT-Bs having nursing degree status and $ETCO_2$ utilisation (pp-value: 0.08640.0864). Therefore, relating to the broader community of EMT-Bs, one does not have to have Nursing Degree to be able to use capnography as a POCT tool (Table 90).
EMT-Bs exposure to capnography were mainly from vocational training conducted at National Ambulance. Most of the EMT-Bs (89.7%, n = 252) still use the conventional methods of assessing patient ventilations by observing chest excursions including 85.8% (n = 241) that reported using the stethoscope. A large proportion of respondents (78.3%, n = 220) have reported to have used capnography (as a POCT tool) in assessment of ventilations but, this is not supported in actual utilization rates observed in historical trends with only 4.98% (n = 1987) use of capnography in the caseload over the study period.

In line with recommended practice, EMT-Bs perceptions of value for capnography use in the Placement of Supra-glottic Airways (SGAs) was 78.9% (n = 202), as a tool to guide ventilation using the Bag Valve Mask (BVM) (93.3%, n = 237), to manage Traumatic Brain Injury (TBI) Patients (93.8%, n = 240), to monitor quality of Cardio-Pulmonary Resuscitation (CPR) (97.2%, n = 249) and to predict the possible outcome of a CPR event (94.5%, n = 241) despite limited exposure, training and education at an EMT-B level of care.

Emerging trends of capnography use by the EMT-Bs showed some appreciation of its' use albeit at a lower rate of acknowledgement. Feedback received from EMT-Bs related possible capnography use, 65.6% (n = 168) EMT-Bs acknowledged its use to monitor spontaneous breathing fully alert patients and 87.9% (n = 225) EMT-Bs felt that it could be used to determine the risk of deterioration in Covid-19 patients.

In general capnography use in the diagnostic detection of Return of Spontaneous Circulation (ROSC) was acknowledged by 66,8% (n = 171), and the diagnostic detection of hypoventilation in the treatment of TBI patients was correctly identified by 61.3% (n = 157) EMT-Bs. While the diagnostic detection of broncho-constriction by EMT-Bs was 44.1% (n = 113) and diagnostic $ETCO_2$ values of adequate CPR being performed were not so well interpreted. Taken in context, there may be confounding factors for these findings but, also serves to highlight a potential gap in knowledge. The confounding factors was not further evaluated due to the limitations of the study and warrants further research. However, capnography was well used in (CPR) resuscitation cases with positive outcomes highlighting appropriateness and effectiveness of use at EMT-B level of care.

Capnography was found to be easy to set-up and to use in the pre-hospital setting, at EMT-B level. It is encouraging that most EMT-Bs (74%, n = 188) felt with certainty, that capnography can help them deal with some of the patient conditions that they are exposed to, this highlights the perceived diagnostic value that EMT-Bs in the northern emirates of UAE. The education and training exposure was perceived as very useful by 74.4% (n = 189) of EMT-Bs. Although, a structured capnography programme on its own, is yet to be formulated in the current setting.

Supporting guidelines such as the Patient Care Protocols (CGP 134), were found to be adequate by 71.3% (n = 181) EMT-Bs. This result also highlights the gap and opportunity for revision of policy and procedures, if capnography was going to be considered for inclusion at EMT-B level of practice. This can be considered together with a monitoring and audit system, to foster safe practice and quality standards.

From a safety perspective most EMT-Bs (84.2%, n = 213) felt little or no pressure, in being forced to use capnography. While some respondents (36.8%, n = 93) observed capnography values but occasionally and often did not use the information to further treat the patients. The reasons for the non-use of the capnography results were not further investigated at this stage. It must also be reported that, perceived unreliable or inaccuracy in capnography recording were occasionally experienced as perceived by 50.2% (n = 127) of the respondents, this is concurrent with literature findings that capnography may be prone to error and should be viewed as an adjunctive tool in decision making, and that patient condition should be considered holistically not base on a single variable only.

EMT-Bs (44.7%, n = 113) are of the opinion that they can most times cope with capnography use at EMT-B level of care and 39.5% (n – 100) feel that they can adequately cope, but both groups acknowledge that further training and support will help with capnography use.

Although there was no gender bias (*p-value*:0.906) detected in the use of capnography, the potential opportunity for capnography use, in the UAE should be considered, to afford a more conservative approach in assessing patients. Using capnography to assess ventilation rates and quality of breathing may be better tolerated by patients of the opposite gender in a Muslim community, oppose to exposing the patient and trying to listen using a stethoscope. While, the stethoscope still has value, capnography as an adjunctive tool can provide more objective parameters in patient assessment in conjunction with conventional tools. To encourage future use of capnography at EMT-B level the availability of the capnography tools to do the job that was found to be available by 71.5% (n = 181) of EMT-Bs, but this should be closer to 100% availability. Education and training stand out as the overall greatest need, in all identified categories for capnography use by EMT-Bs (80.1%, n = 225) surveyed.

EMT-Bs based in the northern emirates of UAE acknowledge, that capnography is more helpful than a hindrance in their supporting their diagnostic ability. They also recognise the good value capnography provides in certain categories of patient care however, the need for greater educational support is required. The opportunities for capnography application by these frontline staff certainly exist and skill shifting to the EMT-B cadre of staff can make positive impact on frontline patient care in a safe manner.

6.2. Recommendations

The $ETCO_2$/capnography inclusion into the EMT-B scope of practice shows promise and can be more enabling, than a hindrance at a basic level of care. However, to enable staff in using the POCT tool, a well-managed, targeted programme can encourage sustainability.

Provided that there is intention for the possible inclusion of capnography into EMT-B scope of practice, the process can be informed by research, best practices and behavior change models. The trans-theoretical model for behavior change, may serve as an option to chart the way forward for safe capnography practice (Wayne W. LaMorte, 2019; Prochaska & DiClemente, 1982).

It is acknowledged that the formulation of a structured programme can help deal with behavior change as in the case of the EMT-Bs, having to adapt to a new skill or enhancement of existing skills (Prochaska & DiClemente, 1982). However, a targeted programme alone may not be sufficient, and may require a multi-pronged concurrent approach to introducing a concept like capnography, especially at a junior level. Creating a conducive environment in the workplace with support from peers, colleagues and supervisors can support learning (Wayne W. LaMorte, 2019). Unilateral upskilling strategies with all stakeholders involved may allow strength to be drawn from each other in support of a new skill addition.

Education stands out as a major contributor to staff development and scope enhancement, as was highlighted in the current study (Table 54). Providing educational opportunities through structured learning activities that include formal programmes on capnography, targeted at EMT-B level can be a conventional route to equip staff with some required learning, but does not have to be limited to didactic methods. Beyond the classroom boundaries, adult education through exposure to conferences and research papers on capnography, can drive innovation and learning and should be encouraged (Wayne W. LaMorte, 2019). Research and development may be a powerful tool in leading change and, establishing a culture of progress in the organization. Given the current surge in online activity in distance learning and research the increased accessibility to learning online has grown exponentially (De', Pandey and Pal, 2020). Developmental activities may be more amenable to staff involved in shiftwork with the flexibility that the online platforms afford learners.

Irrespective of method of delivery, refresher courses from previous education and training initiatives that have supported capnography learning and exposure in the past, could also have value. In the study finding EMT-Bs, benefited most from their primary EMT training and also from short courses attended at National Ambulance (Table 71). Therefore, refresher on already established learning activities that have shown benefit, can serve to reinforce the staff foundational knowledge and experiences.

As part of the multi-pronged approach, encouraging a professional environment where the enhanced skills are included in the extended scope of practice, should be registered with the regulating bodies such as the Department of Health (DOH) or qualifications authority. This can also help standardize and regulate enhanced scope of practice in the long term. However, licensing and credentialing within the organization would probably be easier to achieve in the short-term (Wayne W. LaMorte, 2019). Also, at organization level, establishing clear policies, procedures and guidelines/protocols to guide and support clinical practice in terms of capnography use, can provide clarity to all stakeholders involved. Although, some of these regulations may exist, there is always opportunity for revision and refinement. Especially, in the implementation of new initiatives that can serve to support staff and address safety concerns as with capnography use. Regulatory systems also foster accountability which, is an important component of clinical practice (Rappaport, *et al.*, 2014). Well, considered policy and guideline for clinicians can serve to protect the patient, practitioner, and the organization. Be it from litigation, unsafe practice, management control or clinical quality control, the regulatory framework would be an essential component in promulgating enhanced clinical practice. Together with regulation, the tools for the job, need to be in place if capnography use is encouraged.

Although the study highlighted that the capnography adjuncts was largely available to frontline crew, this would always need to be improved to ensure availability of capnography equipment and sundries to all EMT-Bs that may require them. Regulation, the primary equipment

availability, and the ability to use the POCT tool as intended, are interrelated and speaks to sustainability. However, oversight of these parameters needs to be managed. Therefore, implementing a monitoring system for capnography use in the EMS system would be crucial in the early stages. This should include a robust audit system that can identify risks and trigger measures to mitigate them, as well as steer quality control and monitoring of a newly acquired skill-set (Chartier, *et al.*, 2021).

6.3. Finally

EMT-Bs operating in the northern emirates of UAE have demonstrated the potential to use capnography as a POCT tool to support their diagnostic abilities. They have shown in the medical records that capnography can been used appropriately for relevant pathologies, while the risks have been perceived to be relatively low. It must be taken into account that capnography has not been formally implemented at EMT-B level of care, nor were the EMT-Bs compelled to use the technology from an operational perspective. In the face of rapidly developing technologies and advancements in artificial intelligence (AI), especially in the medical fraternity, EMS needs to take bold strides to keep-up. The call for education and training support must be heeded together with the creation of a conducive environment for adoption of new technologies, while risk mitigation can be controlled through quality and audit systems. Although the possibility of capnography inclusion into the EMT-B scope of practice has good potential, patient outcomes of such an initiative, warrants further research. Empowering frontline EMT-Bs can have a significant impact on quality of patient care, and in bridging the gap in technological advancements in EMS. This study unpacked the documented practice of $ETCO_2$ utilization in the UAE and enquired into related practitioner perceptions. These findings may prove useful to service administrators, quality assurance champions, EMT-Bs, educators and POCT researchers.

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8. Appendices

Annexure A – Cape Peninsula University of Technology Ethics Approval Document
Annexure B – CEO Letter of Application
Annexure C – EMT-B Scope of practice document
Annexure D – Dataset Requirement Tables
Annexure E – EMT-B Survey Tool on $ETCO_2$
Annexure F – Application to use National Ambulance SurveyMonkey® Platform
Annexure G – National Ambulance Research Committee Approval
Annexure H – National Ambulance Pathology Codes
Annexure I – Study Dataset

8.1. Annexure A – Cape Peninsula University of Technology Ethics Approval Document

Cape Peninsula
University of Technology

HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HWS-REC)
Registration Number NHREC: REC- 230408-014

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16 July 2020
REC Approval Reference No:
CPUT/HW-REC 2020/H9

Faculty of Health and Wellness Sciences

Dear Mr A Khan,

Re: APPLICATION TO THE HWS-REC FOR ETHICS CLEARANCE

Approval was granted by the Health and Wellness Sciences-REC to **Mr A Khan** for ethical clearance. This approval is for research activities related to research for **Mr A Khan** at Cape Peninsula University of Technology.

TITLE: Prehospital Point-Of-Care-Testing in the United Arab Emirates: Capnography and related diagnostic capability among Emergency Medical Technicians – Basic.

Supervisors: Mr LD Christopher
Dr N Naidoo

Comment:

Approval will not extend beyond 17 July 2021. An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the HWS-REC in December of that particular year, for the HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

M. le Roes-Hill

Dr Marilize Le Roes-Hill
Acting Chairperson – Research Ethics Committee
Faculty of Health and Wellness Sciences

8.2. Annexure B – CEO Letter of Application

Cape Peninsula University of Technology

04 May 2020

Mr. Ahmed Al Hajeri
CEO: National Ambulance
Abu Dhabi
UAE

Re: REQUEST FOR APPROVAL TO UNDERTAKE RESEARCH

I am a dedicated staff member at National Ambulance and am committed to highlight the excellent standard of service that we bring to the UAE people. National Ambulance have invested in high quality ambulances, equipment and people in-line with the Vision: "To be the Paramount pre-hospital care provider in the UAE." Every ambulance has a LifePak 15 monitor and our EMT-B staff are doing 12 Lead ECG's, Non-Invasive Blood Pressures, Oxygen Saturation and Temperature Point-of-carer tests. Now we are also leading by conducting capnography ($ETCO_2$) tests and monitoring at EMT-B level of care which, very few countries in the world (if any?) that can acclaim with frontline staff on every ambulance. Therefore, I want to take this opportunity to showcase the quality of care that we provide through research.

Currently, I am registered with the Cape Peninsula University of Technology, through the Department of Emergency Medical Care and Rescue with the aim of completing a Masters Degree in Emergency Medical Care (MEMC).

Student Name: Afzal Khan (NA 958) Student Number: 220526133

Supervisor (Primary): Mr. L. D. Christopher Contact Details: +27 82 337 2647 (mobile); LloydC@cput.ac.za (e-mail); Office Number: Routed to Mobile (COVID19 precaution).

Supervisor (External): Dr N. Naidoo Contact Details: +27 83 326 9428 (mobile) NaidooN@cput.ac.za (e-mail); Office Number: Routed to Mobile (COVID19 precaution).

Title of the Research:
Prehospital Point-of-Care-Testing in the United Arab Emirates: Capnography and related diagnostic capability among Emergency Medical Technicians – Basic.

Aim of the Research:
The purpose of this study is to determine how the enhancement of point-of-care testing (POCT) through Capnography enhance the diagnostic capability of EMT-B's in the northern emirates of UAE.
In the context of EMT-B's increased scope of practice in the UAE, the relationship between POCT capnography and diagnostic capability is undocumented. Such knowledge could inform how scope changes can be supported for EMT – B's. That the focus of this study (due to limited study scope) will be on airway, breathing and some circulatory considerations, nuances the

study relevance. This 2-part study will entail the review of ETCO2 utilization trends initially using the database records, and the second phase will comprise of an online survey to determine the EMT-B's perceptions of capnography and it's use in the northern emirates. Thus far, it seems that we have good outcomes from resuscitation and $ETCO_2$ is used as a quality indicator as recommended by the American Heart Association (AHA). Therefore, in the proposed study this (use of $ETCO_2$) will be quantified in this category, as well for the use in other conditions like Head Injuries and Respiratory Compromise.

The Benefits of the Research

National Ambulance may be in a position to showcase the level of technology that the service offers and also the extended scope at which our EMT-B's are operating. The study may also highlight any areas of support that we can offer the EMT-B's (if any) to support patient care. As a result of the study many publications can be produced to the credit of National Ambulance. This may also be opportunity to pave the way for other organizations to follow in the uptake of capnography use, as is advocated by many of the stakeholders (AHA, NEARMT, Universities and others) in the emergency care fraternity.

To proceed further with this study, I would need your permission and support before getting Ethical clearance from the Cape Peninsula University Ethics Committee. In order to be transparent, a hard-copy of the Research Proposal will be made available to you for review.

My commitment to National Ambulance is genuine and I undertake to comply with the following ethical principles. The scientific integrity, study design and methodology will be based on credible literature source. Any obtained data will be handled with the strictest of confidentiality with password protection and limited access. Patient personal information will not be included in the study. All participants will remain anonymous and participation will be voluntary. The online survey can be done at the staff member's leisure, so no pressure to complete in work time. Patient care will not be compromised as this is a retrospective study. The process and content of the study will be informed by rigorous literature review and based on international best practice. The study will be guided by established researchers to ensure process and quality standards. Lastly, all finding will be submitted to you.

I, hereby respectfully request your blessing and support in this initiative and promise not to bring National Ambulance into any disrepute. Permission is requested for access to limited data from the database (mined by IT Department, so I don't have direct access) and also to conduct the online survey with EMT-B's in northern emirates please!

As mentioned previously, a complete Research Proposal will be handed to you prior to the commencement of the study. However, if there is any question or concern please contact me, or any of my supervisors on the details provided in this request for your approval.

Yours Sincerely

AKhan

Afzal Khan (NA 958)
NE HEMS Paramedic

APPROVED ☑ NOT APPROVED ☐

8.3. Annexure C – National Ambulance Research Committee Application

الإسعاف National
الـوطـنـي Ambulance

APPROVAL OF CLINICAL PRIVILEGES
Emergency medical technician – Basic – Extended Scope of Practice
CGF 169

LINK TO POLICY

LINK TO PROCEDURES & FORMS

الإسعاف National
الـوطـنـي Ambulance

Approval of Clinical Privileges – EMT Basic

Under Clinical Services CGP 150 Clinical Governance Policy and CGP203 Fitness to Practice Policy and Procedure, _____ is hereby granted Clinical privileges to function under CGP134 the National Ambulance Patient Care Protocols at the **EMT Basic – Extended Scope of practice Level** of licensure and practice. These are based on the current legal and regulatory requirements of the Ministry of Health and the Department of Health Abu Dhabi. **Please view this approval alongside the scopes and competencies in CGP203.**

Clinical privileges are determined based on prior training, skills, competency assessment and validation. Below are the competencies of a **EMT Basic – Extended Scope of practice Level** under CGP203 Fitness to Practice, those items that are not excluded with strikethrough below are the privileges at the **EMT Basic – Extended Scope of practice Level** for:

_____

This approval of Clinical Privileges is not to be considered permanent, the licensed healthcare professional must maintain their fitness to practice in accordance with the Fitness to Practice policy.
Privileges are granted by the Medical Director and may be revoked or restricted at any time. e.g in case his /her DOH / MOH license is cancelled and / or the clinical training requirements are not met.

_____ _____

Approved by Medical Director Date

Name _____

EMT Basic
Diagnostics
Use of non-invasive diagnostic devices to take and record vital signs, point-of-care testing incl. blood glucose monitoring, SaO2, ETCO2, temperature etc,
Primary and Secondary Assessment (Medical/Trauma)
Maintain and monitor stable patients during transport with any IV medication infusions or procedures done in a medical facility
Monitor or assist with monitoring of all vital signs including basic rhythm ECG as per privilege level
Procedures
Provide basic life support and basic trauma life support
Basic airway adjuncts
Oxygenation & Ventilation support
Suctioning
Foreign body airway obstruction management
Bag Mask, CPAP /BIPAP Ventilation
Laryngeal Mask Airway LMA
Supraglottic Airway Devices (I-Gel)
Automatic/Semi-automatic External Defibrillator (AED)
Basic first aid
Cervical spine care and stabilization
Musculoskeletal injuries care and stabilization
Mass casualty incident procedures
Prepare and assist with on-scene support to ILS, ALS, and Physician
Prepares for labour and supports delivery in uncomplicated cases
Place Patients on stretchers and load into ambulance to/from health facilities
Insert Intravenous line

Competencies – Medication Routes
Oral
Aerosal Spray
Sublingual
Intramuscular injection • Adrenaline (1:1000) • Glucagon
Nebuliser
Intravenous Fluid Resuscitation
Intravenous line for Adrenaline 1:10000 for CPR

Competencies - Miscellaneous
Transportation of stable patients with in-hospital interventions
Drive Ambulances or assist ambulance drivers in transporting patients
Typically operates as part of a 2 person crew, operating from an ambulance that is equipped with a defined set of equipment and medications
Remove and replace soiled linen and equipment to maintain sanitary conditions
Complete Patient care record (ePCR/PCR)
Replace supplies and disposable items
Complete vehicle related documentation, prevention maintenance and checks of vehicles
Demonstrate general effective communication skills in their role
Communicate effectively with the public, colleagues and external stakeholders
Demonstrate effective use of appropriate technology in their role for Information and communication technology
Demonstrate effective use of appropriate technology in their role for Accessing and utilising data sources
Adopt a professional approach to their practice through attitudes, ethical understanding and legal responsibilities
Adopt a professional approach to their practice through Pre-hospital emergency care operational procedures
Demonstrate a commitment to continuous professional competency and personal development

Name _____

الإسعاف National
الوطني Ambulance

DOCUMENT CONFIGURATIONS CONTROL DATE

A review and update of this document will take place as necessary, when changes occur that identify the need to revise this Policy such as changes in roles and responsibilities, release of new legislative or technical guidance, or identification of a new policy area.

This document ownership for editing is identified as:

Medical Director

Change Brief

Version No.	Date	Changes
1	29 November 2018	New form specific for approval of clinical privileges for healthcare professionals
2	October 2019	Update the validity of the privileges

_____ _____

Dr. Ayman Ahmad – Medical director Date

Review & Approval

8.4. Annexure D – Dataset Requirement Tables

Patient Care Records (PCR) - Data Variables for $ETCO_2$ Study							
Generic Details:	**For Inclusion (Study Variables)**	**For Exclusion (not required for study)**		**KEY**			
1. Crew Identifiers (Crew Numbers)		Crew Identifiers (Crew Numbers)		Within BLS Scope - Variable Required for Study			
2. Date	Date			Within BLS Scope - but NOT Required for Study			
3. Time	Time						
4. Location of Incident	Location of Incident						
5. Incident # Reference	Incident # Reference						
6. Dispatch Priority		Dispatch Priority					
7. Base Station Allocation	Base Station Allocation						
Patient Personal Details							
1. Names		Names					
2. Nationality		Nationality					
3. Triage Category	Triage Category						
4. Date of Birth (DOB)	Date of Birth (DOB)						
5. Gender	Gender						
6. Residential Address Details		Residential Address Details					
7. Next of Kin (NOK) Details		Next of Kin (NOK) Details					
8. Resident Type		Resident Type					
9. Insurance Company & Number		Insurance Company & Number					
Date & Timings							
1. Call Origin		Call Origin					
2. Responding Time		Responding Time					
3. On-Scene Time	On-Scene Time						
4. At Patient Time	At Patient Time						
5. Transporting Start Time		Transporting Start Time					
6. Pre-Alert Time	Pre-Alert Time						
7. Arrival at Hospital Time	Arrival at Hospital Time						
8. Hospital Completion / Departure Time		Hospital Completion / Departure Time					
9. Back at Base/ To Next Call Time		Back at Base/ To Next Call Time					

Patient Medical History							
1. Allergies		Allergies					
2. Past Medical History		Past Medical History					
3. Last Oral Intake		Last Oral Intake					
4. Patient regular medications		Patient regular medications					
5. Tetanus status		Tetanus status					
6. Patient Weight	Patient Weight						
Incident Details							
1. Mechanism of Injury / History	Mechanism of Injury / History						
2. Vehicle Involved (if RTC) Details		Vehicle Involved (if RTC) Details					
a. Number Plate Type		Number Plate Type					
b. Plate source (location)		Plate source (location)					
c. Plate Code		Plate Code					
d. Plate Registration Number		Plate Registration Number					
e. (Picture of Vehicle Captured as well)		(Picture of Vehicle Captured as well)					
Chief Complaint							
Injury Information (Narrative)							
a. Exact time/ Onset Injury		Exact time/ Onset Injury					
b. Subjective (Hx Presenting Complaint)	(Hx Presenting Complaint)						
c. Objective (findings)	Objective (findings)						
d. Assessment (Obs. & Exam)	Assessment (Obs. & Exam)						
e. Management Plan	Management						
f. BE F.A.S.T.	BE F.A.S.T.						
g. Burns %	Burns %						
h. Time of Onset (Burn)		Time of Onset (Burn)					
i. Diagram of A&P planes for injury / info.		Diagram of A&P planes for injury / info.					
Vital signs (Serial)							
a. Times	Times						
b. Heart Rate	Heart Rate						
c. Respiration Rate	Respiration Rate						
d. Blood Pressure	Blood Pressure						
e. SpO2	SpO2						

f. AVPU / GCS	AVPU / GCS						
g. Temperature	Temperature						
h. FLACC / Pain Score	FLACC / Pain Score						
i. BSL	BSL						
j. PEFR		PEFR (not Captured)					
k. $ETCO_2$	$ETCO_2$						
l. Shock Index (SI)	Shock Index (SI)						
m. Early Warning Score (EWS)	Early Warning Score (EWS)						
Management Options							
a. Airway							
i. Manual							
ii. OP/NP	OP/NP						
iii. LMA / i-Gel®							
iv. ET Tube, Size & Length							
v. Surgical Airway							
b. Chest							
i. Ventilated							
ii. BVM	BVM						
iii. ICC		ICC					
iv. L/R		L/R					
c. Circulation		Circulation					
i. IVI		IVI					
ii. Site		Site					
iii. Size & No of attempts		Size & No of attempts					
iv. ECG & Findings		ECG & Findings					
d. Immobilization							
i. C/ Collar		C/ Collar					
ii. Spinal Board	Spinal Board						
iii. Vacuum Mattress		Vacuum Mattress					
iv. UL & LL Splints		UL & LL Splints					
v. Femur Splints		Femur Splints					
vi. Pelvic Splints		Pelvic Splints					
e. Transport		Transport					
i. Yes/ No		Yes/ No					
f. Chem Panels							
i. PH							
ii. pCO2		ii. pCO2					
iii. pO2		iii. pO2					
iv. HCO3		iv. HCO3					
v. Na		v. Na					

vi. Ca		vi. Ca					
vii. TNT		vii. TNT					
viii. BE		viii. BE					
ix. SaO2		ix. SaO2					
x. K		x. K					
xi. Hct		xi. Hct					
xii. Hb		xii. Hb					
xiii. AnGap		xiii. AnGap					
9. Hospital Handover							
a. Hospital	Hospital Name						
b. Name		b. Name					
c. Designation of receiving staff		c. Designation of receiving staff					
d. Time of Handover	Time of Handover						
e. Signature		Signature					
f. Patient Hospital Identifier		Patient Hospital Identifier					
g. Working Diagnosis	Working Diagnosis + Coding						
h. Free Text		Free Text					
i. Diagnosis	Diagnosis						
ii. Other Relevant information		Other Relevant information					
iii. Comment		Comment					
i. Adverse Event		Adverse Event					
j. Death		Death					
k. Event Details		Event Details					
l. Prolonged Scene Times		Prolonged Scene Times					
10. Early Warning Score (EWS)	Early Warning Score (EWS)						
11. Shock Index	Shock Index						
12. Back Up Support	Back Up Support						
13. Consent		Consent					
a. Patient made aware of rights		Patient made aware of rights					
b. Agreement for treatment		Agreement for treatment					
c. Agreement for transport		Agreement for transport					
d. Patient Capacity		Patient Capacity					
14. Fall risk		Fall risk					

15. Does the patient Require Transport?		Does the patient Require Transport?					
16. Refusal Advice		Refusal Advice					
17. Signature		Signature					

Associations & Correlations

Variable 1	Values	Variable 2	Numerical Value	Correlation Value
Base Station Allocation	Discrete	EtCO2 Recoding	Discrete	Indication of Demographic Use ETCO2
Head Injury	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Head Injury Patients
Respiratory Pathology	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Respiratory Patients
Respiration Rate	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Respiration Rate calc.
Working Diagnosis / Code	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for specific Pathologies (like Asthma)
OP/NP	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for patients with decrease LOC
BVM	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use as guide for BVM application
Shock Index	Continous	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Shock Index Patients
Time CPR Started EMS/Private	Continous	EtCO2 Recoding	Discrete	Indication of ETCO2 use in Resuscitation
Mechanical CPR Device used	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Resus with Mechanical Device
PreHospital Advanced Airway (SGA)	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for SGA Placement
Triage Category	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use according to Traige Rating
Return of Spontaneos Circulation	Discrete	EtCO2 Recoding	Discrete	Indication of ETCO2 use for Return of S Patients
At Patient Time	Contionous	Arrival at Hospital Time		Indication of Total Patient Contact Time
Time EMS Arrived at Patient side	Continous	Time Ambulance Arrived at ED		Indication of Resuscitation Contact Time
Base Station Allocation	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$
Head Injury	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Head Injury
Respiratory Pathology	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Respiratory Pathology
Respiration Rate	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ to assess Respiratory Rate
Working Diagnosis / Code	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ accoding to Working Diagnosis
OP/NP	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Obtunded Patients
BVM	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for patients being Assist Ventilated
Shock Index	Continous	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for patients in Shock
Time CPR Started EMS/Private	Continous	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for duration of Pt. contact time
Mechanical CPR Device used	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for measuring Quality of CPR
PreHospital Advanced Airway (SGA)	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ for Confirming placement of SGA
Return of Spontaneos Circulation	Discrete	**NO** - EtCO2 Recoding	Discrete	Indication of Non-use of $ETCO_2$ and association with ROSC

KEY
Variable 1 to be Correlated to Variable 2
Variable 2 to be Correlated with Variable 1
Result of Correlation between Variables 1 & 2

Mulitple Correlations

Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Value of Correlations
Head Injury (Coding 12)	Respiratory Pathology (Coding 05)	Resuscitation (Coding 06)	Shock (Coding 04/ Uncoded)	Other Diagnosis (Coded)	An Indicator of Pathology Bias
Male	Female				Indicator of Gender Bias
Ajman	Sharjah	Umm-Al-Quwain	Fujairah	Ras-Al-Khaimah	Regional Bias (use / Non-Use)
CPR	Mechanical CPR	ETCO2	ROSC		Different. ETCO2 Val. Mech vs. Normal
CPR	Pre Hospital Drug Therapy	ETCO2	ROSC		Drug Therapy Ass with ROSC
CPR	Pre Hos. Adv. Airway	ETCO2	ROSC		Adv Airway vs BVM Values
CPR	ETCO2	ROSC			ETCO2 Ass with ROSC Highlight
CPR	No ETCO2	ROSC			Quality of CPR Lost Opportunity

KEY
Variable 1 - Head Injury
Variable 2 - Respiratory Pathology
Variable 3 - Resuscitation
Variable 4 - Shock
Variable 5 - Other Working Diagnosis
Result of Correlation (V1-V5)

8.5. Annexure E – EMT-B Survey Tool

SURVEY

Survey: Prehospital Point-of-Care-Testing - Capnography and diagnostic capability of Emergency Medical Technicians-Basic in the United Arab Emirates

Information Sheet for participants

Researcher

Afzal Khan (N Dip AEC, BTech EMC, HD Ed, MEMC Candidate)

Contact Details: (Removed)

NB. If you have any queries, concerns or comments about this study or you require more information, you are welcome to contact the Researcher on the details as displayed above.

Supervisors

1. Mr Lloyd Denzel Christopher (N Dip AEC, BTech EMC, HD Ed, MTech EMC)

Primary Supervisor/Head of Department: Emergency Medical Care & Rescue, Faculty of Health Sciences, Cape Peninsula University of Technology, South Africa.

Contact Details (Removed)

2. Dr Navindhra Naidoo (N Dip EMC, BTech EMC, HD Ed, MPH, PhD (Forensic Medicine))

External Supervisor/Senior Lecturer: Emergency Medical Care & Rescue, Faculty of Health & Wellness Sciences, Cape Peninsula University of Technology, South Africa.

Contact Details: (removed)

Welcome

Welcome to this 'Capnography and diagnostic capability of EMT-Bs in UAE' Survey.
All EMT-B staff are kindly requested to participate.
I would like to thank you, for your participation in this survey. Your time, effort and valuable contribution is sincerely appreciated.

Purpose

The purpose of this study is to determine how the implementation of Capnography are experienced by the EMT-Bs in the UAE. In order to achieve this, the survey intends to document the EMT-Bs self-perception of the inclusion of $ETCO_2$ in their clinical scope, its application and challenges.

Research Ethics

There is no risk to the participants in this study. All data collected will be secured and accessible the researcher alone under password protection. This study is approved by National Ambulance Management as well at the NA Research Committee. Further, this study is also approved by the Human Research Ethics Committee of the Cape Peninsula University of Cape Town and therefore, participants are assured that there is rigorous ethical compliance. The researcher is also an Emergency Care Practitioner and has professional accountability.

In the very unlikely event that any risk, threat is perceived or untoward event occurs please contact the Researcher, or Line Manager or Report the matter through the Quality Health and Safety System (QHSE) at National Ambulance for further support.

Researcher Details: Afzal Khan, (Removed)
Line Manager: Contact via Communication Centre: (Removed)
QHSE: Access (Removed) and click on Controlled Documents Tab (Guidance & Docs)

Potential Benefits

There are no direct benefits to participants as individuals however, the participant will be making a contribution to the knowledge of EMS clinical practice in the UAE and may inform the greater EMS Community. The level of EMT-B Practice at National Ambulance may also be highlighted to showcase what can be achieved at EMT-B Level.

Payment for Participation

Participants of this study will not be remunerated in any way.

Confidentiality

The researcher will maintain confidentiality of all personal information. This will be achieved by ensuring that there will be no identifying information on details derived from the study. Answers provided to open questions may be used as part of the study report but limited to statistical purposes only .

Participation

Participation in this study is voluntary. Should you wish to withdraw from the study, you may contact the researcher (on the details supplied above) to have you removed from the study at any time without prejudice.

NOTE:

1. Read the instructions prior to committing to the survey.
2. Completing the survey implies consent but also please acknowledge by selecting the Consent options in the survey.
3. There are 41 responses in this survey. It should take you approximately 15 minutes to complete.
4. Choose an option that best suits your view by selecting the chosen answer tab next to it.
5. There are no right or wrong answers, and this is not an evaluation test, so just answer to the best of your ability.
6. There are some questions that have more than one option that applies to you, select all the relevant options.
7. As a participant in the study, the results will be available to you on completion of the study

"Your time and effort in this survey is most valuable and is sincerely appreciated!"

8.6. Annexure F – (Survey Tool) Phase 3 (loaded onto the SurveyMonkey® Platform)

EMT-Bs' Exposure and Perceptions of Capnography (ETCO2) in Support of Their Diagnostic Abilities

* Required

1. Email address *

Consent

There is no risk to the participants in this study. All data collected will be secured and accessible to the researcher under password protection. This study is approved by National Ambulance Management as well at the NA Research Committee and is also approved by the Human Research Ethics Committee of the Cape Peninsula University of Cape Town (SA) and therefore, participants are assured of rigorous ethical compliance. As a voluntary participant you reserve the right to withdraw from the survey at any time by mailing the investigator at AKhan@nationalambulance.ae (e-mail); and +971 56 596 7106 (Mobile & WhatsApp) for enquiries.

2. I hereby consent to participating in this survey. *

Mark only one oval.

- ◯ Yes
- ◯ No *Skip to section 11 (Non-Consent)*

Demographic Details

This section collects demographic information including the UAE setting, your qualifications and deployment. Please note that the information you provide is confidential and is used for statistical purposes only, and will not be traced back to you for reporting.

3. Please enter your current age in years (as a number). *

4. Please select your gender. *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Prefer not to say
- ◯ Other: _____

5. How many years of experience do you have as an EMT-B in total (at Home Country & UAE)? *

Mark only one oval.

- ◯ Less than 2 years
- ◯ 2 - 4 years
- ◯ 4 - 6 years
- ◯ 6 - 8 years
- ◯ 8 - 10 years
- ◯ More than 10 years

6. Which emirate are you currently deployed to in the UAE? *

Mark only one oval.

- ◯ Sharjah
- ◯ Ajman
- ◯ Ras-al-Khaimah
- ◯ Fujairah
- ◯ Um-al-Quwain
- ◯ Other: _____

7. Please indicate the Operational division you are primarily assigned to: *

Mark only one oval.

- ◯ Ambulance Frontline Operations
- ◯ Aeromedical Operations
- ◯ Administrative Role
- ◯ First Responder
- ◯ Multiple Roles
- ◯ Other: _____

8. Please supply your National Ambulance (NA) staff reference number. (This will be used for statistical reference only and not any means of identification tracing).

_____

Background Qualifications

This section collects information on your qualifications

9. Please select the Medical Qualifications / Courses that you have completed from the list below (multiple options can be selected). The course status does not have to be current.

Check all that apply.

- ☐ Nursing Degree (BSc Nursing)
- ☐ EMT-B Qualification
- ☐ PHTLS (Pre-hospital Trauma Life Support) Course
- ☐ Basic Airway Course
- ☐ ACLS (Advanced Cardiac Life Support) Course
- ☐ PALS (Pediatric Advance Life Support) Course
- ☐ Resuscitation Course (Part of Extended Scope)
- Other: ☐ _____

10. Have you received any exposure to education on ETCO2 / Capnography? *

Mark only one oval.

- ◯ Yes
- ◯ No *Skip to question 13*

ETCO2 Education Exposure

11. Through which programme(s) did you receive ETCO2 exposure? (Select all that apply)

Check all that apply.

- ☐ During training for your primary qualification in home country.
- ☐ During Short courses at National Ambulance in the UAE.
- ☐ Online In-service training
- Other: ☐ _____

12. Through which programme(s) might you have been exposed to ETCO2 Education & Training? (Select all that may apply)

Check all that apply.

- ☐ Primary Qualification: Bachelors Nursing
- ☐ Primary Qualification: Bachelors Emergency Care
- ☐ Primary Qualification: Other _____ (Please Specify) Insert Text Option
- ☐ Short Course: EMT-B
- ☐ Short Course: Basic Airway Course
- ☐ Short Course: PHTLS Programme
- ☐ Short Course: ACLS Course
- ☐ Short Course: PALS Course
- ☐ Onboarding Programme
- ☐ Mentorship Support Exposure
- Other: ☐ _____

Diagnostics

This is not a test, and you are not being graded. This section comprises simple questions related to patient assessment/care and a few capnography waveforms/trends that you may encounter.

13. In EMS Operations, how do you normally assess a patients ventilation status? (Select all that apply)

Check all that apply.

- [ ] By visual observations (chest excursion / use of accessory muscles / skin colour etc.)
- [ ] By listening for breath sounds without A stethescope
- [ ] By listening to breath sounds with a stethescope
- [ ] By feeling for air movement from the patients airway
- [ ] With the use of pulse oximetry (SaO2) (point-of-care test)
- [ ] With the use of capnography (ETCO2) (point-of-care test)
- [ ] Other: _____

14. How do you synchronise (BVM) assisted ventilation with the patients breathing in emergency cases? (Select all that apply)

Check all that apply.

- [ ] Watched for chest excusion and ventilated according to patient's breathing.
- [ ] Administer unsyncronized breaths at the recommended rates irrespective of patient breaths.
- [ ] Used monitoring devices (if available) to guide support ventilation
- [ ] Used the BVM (valve opening) as an indicator to assist ventilation when required
- [ ] Other: _____

15. Can capnography (ETCO2) be used for each of the following? *

Mark only one oval per row.

	Never	Not normally	Possibly	Definitely	Don't know
As an indicator of Supra Glottic Airway (i-Gel) tube placement confirmation	◯	◯	◯	◯	◯
As a tool to guide patient ventilation using a Bag-Valve Mask	◯	◯	◯	◯	◯
To manage oxygenation in Traumatic Brain Injury (TBI) patients	◯	◯	◯	◯	◯
To monitor the quality of cardiopulmonary resuscitation (CPR)	◯	◯	◯	◯	◯

16. Can capnography (ETCO2) be used for each of the following? *

Mark only one oval per row.

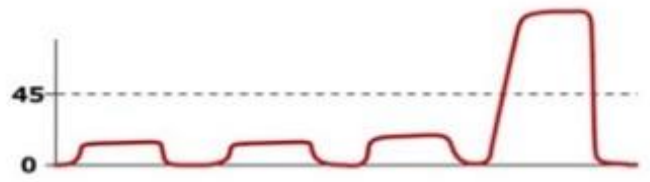
	Never	Not normally	Possibly	Definitely	Don't know
To predict the outcome for a patient that is being resuscitated in cardio-pulmonary arrest	◯	◯	◯	◯	◯
To monitor a patient that is spontaneously breathing and fully alert (GCS 15/15)	◯	◯	◯	◯	◯
To determine risk of deterioration in Covid-19 patients	◯	◯	◯	◯	◯

17. Cardiopulmonary resuscitation (CPR) is being performed on a patient that collapsed. Given the ETCO2 reading displayed on the monitor 18mm/Hg, what does this imply about the CPR being performed? *

Mark only one oval.

- ◯ This is a Normal Capnography value for any patient that is alive.
- ◯ Adequate CPR is being performed
- ◯ Inadequate CPR is being performed
- ◯ This is an indication of Return of Spontaneous Circulation (ROSC)
- ◯ None of the above apply to the Capnography trace shown above.
- ◯ Unsure

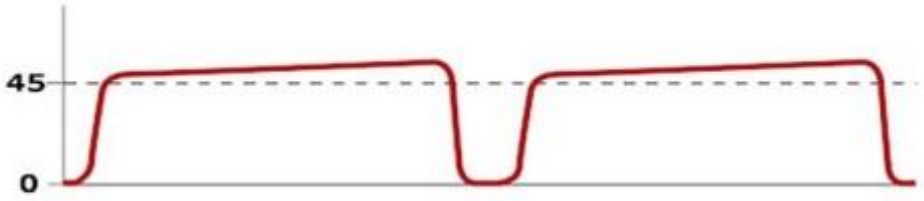
18. After approximately 2 minutes of CPR you notice a sudden change in the graph presented on your monitor with ETCO2 (+ 45mm/Hg). What can you conclude from the capnography graph presented below? *



Mark only one oval.

- ◯ This is a Normal Capnography Trace
- ◯ Adequate CPR is being performed
- ◯ Inadequate CPR is being performed
- ◯ This is an indication of Return of Spontaneous Circulation (ROSC)
- ◯ None of the above apply to the capnography trace shown above.
- ◯ Unsure

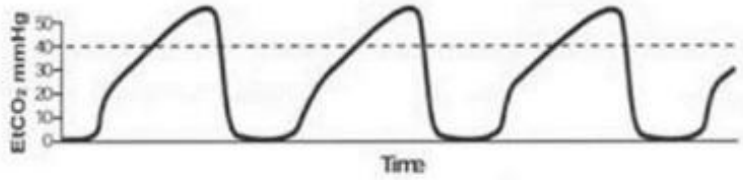
19. You are assisting ventilation in a patient that has a traumatic brain injury. The ETCO2 value has escalated to above 45 mmHg and the Respiratory Rate (RR) was 6/min. The patient has started (Decerebrate) posturing. At BLS level is there anything you can do (based on the graph prresentation) in an attempt to assist this patient from deteriorating as the next step? *



Mark only one oval.

- ◯ Insert an IV Line next
- ◯ Increase Ventilation Rate with a BVM next
- ◯ Decrease the ventilation rate with a BVM next
- ◯ Rapid Transport to hospital next
- ◯ Get ready to do CPR next
- ◯ Unsure

20. In a patient that is experiencing difficulty in breathing, the following capnograph (below) is monitored with a respiritory rate of 20 breaths per minute. What Clue does this graph give you about the patient with difficulty in breathing? *



Mark only one oval.

- ◯ This is a normal capnograph / ETCO2 Waveform
- ◯ The patient is hyperventilating
- ◯ The patient may have Bronchospasm
- ◯ The patient is Choking
- ◯ Unsure

EMT-B Perceptions

These questions relate to the EMT's perception of capnography (ETCO2) use by the EMT-B in the northern emirates of UAE.

21. Were you ever exposed to any capnography (ETCO2) training / education in your 'Extended Scope' or other training courses at National Ambulance? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

22. Have you come across any formal document (policy / protocol / guidelines) at National Ambulance that encourages the use of capnography in patient care? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Other: _____

23. In your opinion can capnography inclusion at BLS level, help you to deal with some patient conditions you are exposed to? *

Mark only one oval.

- ◯ Certainly
- ◯ Probably
- ◯ Unsure
- ◯ Probably Not
- ◯ Certainly Not

24. How useful has the Capnography (ETCO2) Education & Training exposure that you received thus far been in helping you to use capnography as a diagnostic/POCT tool?

Mark only one oval.

- ◯ Completely useless
- ◯ Slightly useful
- ◯ Moderately useful
- ◯ Very useful
- ◯ Extremely useful
- ◯ Not Applicable (I did not have any exposure to capnography (ETCO2) at National Ambulance)

25. How adequate are the Patient Care Protocol (CPG 134) guidelines for the use of capnography (ETCO2)? *

Mark only one oval.

- ◯ Completely inadequate
- ◯ Mostly inadequate
- ◯ Unsure
- ◯ Mostly adequate
- ◯ Completely adequate

Application

This section documents your experiences with capnography (ETCO2) use in the current EMS setting.

26. How easy is capnography (ETCO2) monitoring easy to set-up and use? *

Mark only one oval.

- ◯ Never easy
- ◯ Sometimes easy
- ◯ Usually easy
- ◯ Always easy
- ◯ Not applicable / Don't know

27. Do you find using capnography (ETCO2) helpful in managing patients in any of the categories listed below? (Select all that apply)

Check all that apply.

- ☐ Trauma (Head Injury, Chest Injury, Multiple Trauma)
- ☐ Medical (Respiratory Difficulty, Asthma/COAD)
- ☐ Cardiopulmonary Resuscitation (CPR) Events
- ☐ Psychiatric (OD/Hyperventilation)
- ☐ Covid-19 Cases
- ☐ General Cases
- ☐ Not Applicable (I have not used capnography (ETCO2) in the UAE).

Other: ☐ _____

28. In which of the patient categories listed below would you like to see more education and training for capnography (ETCO2) use? (Select all that apply)

Check all that apply.

- [ ] Trauma (Head Injury, Chest Injury, Multiple Trauma)
- [ ] Medical (Respiratory Difficulty, Asthma/COAD)
- [ ] Cardiopulmonary Resuscitation (CPR) Events
- [ ] Psychiatric (OD/Hyperventilation)
- [ ] Covid-19 Patients
- [ ] Other: _____

29. How often, in your current workplace setting, are the tools required to conduct capnography (ETCO2) available (e.g., LifePak 15 Monitor, ETCO2 Nasal sampling tubes, ETCO2 adaptors etc.)? *

Mark only one oval.

- ◯ Never
- ◯ Occasionally
- ◯ Usually
- ◯ Always
- ◯ Not Applicable (never used capnography - ETCO2) / Unsure

30. Do you receive any Clinical Audit feedback on Capnography ETCO2 use for patient care at any stage? *

Mark only one oval.

- ◯ Never
- ◯ Occasionally
- ◯ Usually
- ◯ Always
- ◯ Not applicable

31. How often do you observe triggers that remind you to use ETCO2 monitoring in cases where there may be value?

Mark only one oval.

- ◯ Never
- ◯ Occasionally
- ◯ Usually
- ◯ Always
- ◯ Not Applicable

Perceived Risks

This section deals with safety in capnography (ETC02) use.

32. How much pressure do you feel from your superiors to use capnography (ETCO2)? *

Mark only one oval.

- ◯ No pressure
- ◯ A little pressure
- ◯ Significant pressure
- ◯ A lot of pressure

33. Have you ever been in a situation where you connected up the ETCO2 sampling line to the monitor and got a value of ETCO2 but did not use the information further to direct treatment? *

Mark only one oval.

- ◯ Never
- ◯ Occasionally
- ◯ Often
- ◯ Always
- ◯ Cannot remember

34. ARE you ADEQUATELY TRAINED TO cope with capnography (ETCO2) technology at BLS Level? *

Mark only one oval.

- ◯ Not at all for BLS level of care (too much for me)
- ◯ Not really (I need further training and support)
- ◯ Most times I can cope (further training and support will help)
- ◯ Yes, I can cope (adequately)
- ◯ Definitely I can cope easily (No further training or support required)
- ◯ Other: _____

35. Have you perceived any ETCO2 recordings to be unreliable/ inaccurate during patient care?

Mark only one oval.

- ◯ Never
- ◯ Occasionally
- ◯ Usually
- ◯ Always
- ◯ Not Applicable (never used capnography on the awake patients)

36. Are there any factors that may encourage you to use Capnography in future? (Select all that apply)

Check all that apply.

- ☐ Further Education / Training
- ☐ Management Support (through policy & procedure)
- ☐ Guidelines Clarity
- ☐ Audit Feedback
- ☐ Peer Support
- ☐ Exposure through practice
- Other: ☐ _____

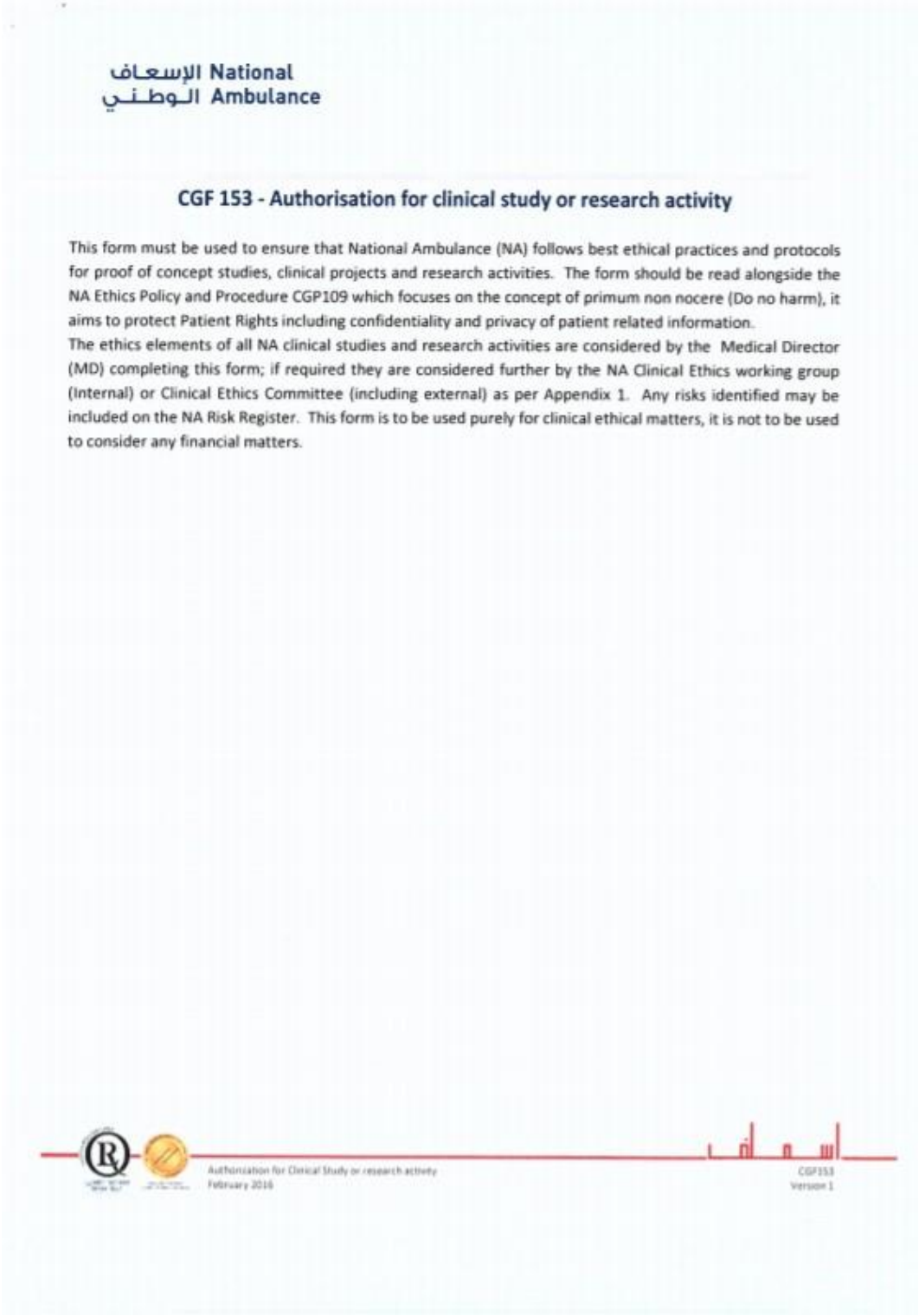
Thank you, for participating in this survey

Your contribution to EMS quality & development is acknowledged and appreciated. On completion of the study you will have access to the outcome of the research and/or any publications.

Non-Consent

As you have indicated that you do not consent to participate in this survey, you may now exit the form.

8.7. Annexure G – National Ambulance Research Committee Approval



الإسعاف National
الوطني Ambulance

CGF 153 - Authorisation for clinical study or research activity

This form must be used to ensure that National Ambulance (NA) follows best ethical practices and protocols for proof of concept studies, clinical projects and research activities. The form should be read alongside the NA Ethics Policy and Procedure CGP109 which focuses on the concept of primum non nocere (Do no harm), it aims to protect Patient Rights including confidentiality and privacy of patient related information.

The ethics elements of all NA clinical studies and research activities are considered by the Medical Director (MD) completing this form; if required they are considered further by the NA Clinical Ethics working group (Internal) or Clinical Ethics Committee (including external) as per Appendix 1. Any risks identified may be included on the NA Risk Register. This form is to be used purely for clinical ethical matters, it is not to be used to consider any financial matters.

الإسعاف الوطني National Ambulance

Name of study/project	**PREHOSPITAL POINT-OF-CARE-TESTING IN THE UNITED ARAB EMIRATES: CAPNOGRAPHY AND RELATED DIAGNOSTIC CAPABILITY AMONG EMERGENCY MEDICAL TECHNICIANS - BASIC**
Name of the investigator	**AFZAL KHAN (NA 958)**
Name of the Co-investigators	**NA**
Study design e.g. Cross sectional	A post-positivist paradigm using a deductive approach is the design adopted for this study. Retrospective Data of a quantitative nature will be collected and analyzed (Phase 1: archival research). In the initial parts of the study, electronic data captured in a database will be mined to extract details required to produce an epidemiological description of ETCO2 practice. Subsequently, a practitioner survey (Phase 2) will be used to prospectively extrapolate perceptions on $EtCO_2$ implementation and related diagnostic experience (Fig 3.). The data retrieved from processes mentioned will need to be put into perspective. Taking into considerations factors such as the local cultural, ethical and political influences here in the Middle East, may be very different to the western world and will need reporting on. The post-positivist paradigm allows flexibility for this type of narrative to supplement the data analysis. **PART 1 – CROSS-SECTIONAL & DESCRIPTIVE** **PART 2 – PROSPECTIVE & DESCRIPTIVE**
Hosted/organised by	**THE RESEARCH IS IN COMPLIANCE WITH A MASTERS DEGREE IN EMERGENCY MEDICAL CARE AND WILL BE HOSTED BY THE CAPE PENINSULA UNIVERSITY OF TECHNOLOGY (CPUT) IN SOUTH AFRICA (SA)**
Period of study	**2020 -2021 ENROLLED STUDY PERIOD**
Population of study	**EMT-B POPULATION OF THE NORTHERN EMIRATES (ESTIMATED N:448)**

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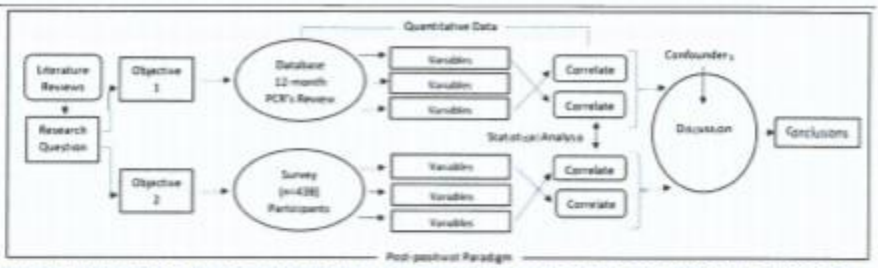
Methods



PHASE 1 INVOLVES A LITERATURE REVIEW. AN EXTENSIVE NARRATIVE ANALYSIS WILL EXPLICATE THE FACTORS ASSOCIATED WITH POCT CAPNOGRAPHY, AND PREHOSPITAL DIAGNOSTIC PRACTICE. THE LITERATURE REVIEW WILL INFORM THE PROBLEM DESCRIPTION AND FACTOR ANALYSIS TO BE CONSIDERED IN PHASE 2.

IN PHASE 2, A REVIEW OF ELECTRONIC PATIENT CARE RECORDS WILL BE CONDUCTED TO DETERMINE THE QUANTITATIVE TRENDS OF CAPNOGRAPHY UTILISATION. UNDERSTANDING CAPNOGRAPHY PRACTICE FROM MEDICO-LEGAL RECORDS WILL INFORM THE SURVEY PARAMETERS.

PHASE 3 INVOLVES USING A PROSPECTIVE, DESCRIPTIVE, ONLINE SURVEY, QUANTITATIVE DATA ON CAPNOGRAPHY IMPLEMENTATION WILL BE GATHERED. THE SURVEY QUESTIONS WILL BE INFORMED BY THE PHASE 2 FINDINGS. THIS METHOD ALIGNS TO OTHER STUDIES OF A SIMILAR NATURE (WYLIE, ET AL., 2019).

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Risks and risk management	TO DESCRIBE CONCISELY THE ANTICIPATED BENEFITS OF THIS RESEARCH FOR SOCIETY AND EXPLAIN HOW THE BENEFITS OUTWEIGH THE RISKS. IN THE INITIAL PART OF THE DATABASE REVIEW OF THE PATIENT CARE RECORDS THAT WILL BE DIGITALLY MINED, THERE IS MINIMAL RISK ANTICIPATED AS THE DATA WILL BE RETROSPECTIVE. SC NOT IMPACTING ON PATIENT CARE OR STAFF INVOLVED. THE BENEFITS OF THIS PART OF THE STUDY IDENTIFY UTILIZATION TRENDS AND GAPS WILL BE USED TO INFORM FUTURE PRACTICE ANI IMPLEMENTATION ENABLING THE PRACTITIONER FOR HIGHER PATIENT CARE QUALITY. THE SECOND PART OF THE STUDY WILL BE PROSPECTIVE BUT DOES NOT INVOLVE PATIENT INTERACTION OR ANY PARTICIPANT CLINICAL ACTIVITY. THE STUDY WILL BE LIMITED TO A SURVEY RESPONSE. THE BENEFIT ON THE OTHER HAND WILL ONLY SERVE TO SUPPORT PATIENT CARE AND THE PARTICIPANT, AS PER THE PARTICIPANT PERCEPTION OF THEIR NEEDS.

Authorised by Medical Director	(Yes)	No
Referred to Clinical Ethics working group (internal)	Yes	(No)
Referred to Clinical Ethics committee (including external)	Yes	(No)
Comments To Conduct the research according to N.A policies.		

Removed

Signature _____ Dr. Ayman Ahmed Medical Director

Date 09/07/2020

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DOCUMENT CONFIGURATIONS CONTROL DATE

A review and update of this document will take place as necessary, when changes occur that identify the need to revise this Policy such as changes in roles and responsibilities, release of new legislative or technical guidance, or identification of a new policy area.

This document ownership for editing is identified as:

Medical Director Change Brief

Version No.	Date	Changes
1	28 January 2016	New Document to support CGP109
2		
3		

Review & Approval:

Removed

09/7/2020

Dr. Ayman Ahmed Medical director Date:

8.8. Annexure H – National Ambulance Pathology Codes

1.	Abdominal/ Back Pain
2.	Allergic Reaction
3.	Infectious Disease
4.	Bleeding (Non-trauma)
5.	Breathing Difficulty
6.	Cardiac Arrest
7.	Chest Discomfort/ Heart Problems
8.	Choking
9.	Diabetic
10.	Environmental/ Toxic Exposure
11.	Medical Knowledge (Facility)
12.	Head/ Neck
13.	Mental/ Emotional/ Psych
14.	O.D./ Poison
15.	Pregnancy/ Childbirth/ GYN
16.	Seizures
17.	Sick (Unknown)/ Other
18.	Stroke (CVA)
19.	Uncons/ Sync/ Unresp/ Weak
20.	Pediatrics
21.	Assault/ Trauma
22.	Burns/ Therm/ Elec/ Chem
23.	Drowning/ Water Injury
24.	Falls/ Accidents/ Pain
25.	Motor Vehicle (MVA)
26.	Animal Bites
27.	Standby
28.	Deceased
29.	No Inj/ Illness

8.9. Annexure I – Study Dataset