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Association between an electronic non-transport checklist and the mortality of patients discharged-at-scene by paramedics in New Zealand: A retrospective cohort study.

2021

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A thesis submitted to Auckland University of Technology in fulfilment of the requirements of the degree of Master of Philosophy (MPhil)

Abstract

New Zealand paramedics increasingly discharge patients at scene instead of transporting them to hospital. This change in practice has developed in response to greatly increased low-acuity workload – an increase exceeding population growth. These changes are typical of trends in Emergency Medical System (EMS) workload and practice in high-income countries worldwide. However, the outcomes of patients discharged-at-scene are poorly understood and the safety of this change in EMS practice is unknown. New Zealand paramedics use an electronic non-transport checklist (eNTC) to support discharge-at-scene decisions, but the effectiveness of this checklist in reducing the rate of adverse outcomes from discharge-at-scene is also unknown.

The aim of this thesis is to explore the association between using the eNTC and mortality of patients discharged-at-scene by paramedics in New Zealand by a) establishing the 1-, 3- and 7-day mortality of patients discharged-at-scene by paramedics in New Zealand, b) establishing the frequency of eNTC use, c) identifying any association between eNTC use and 7-day mortality, d) identifying variables associated with 7-day mortality (other than eNTC use) and e) identifying variables associated with eNTC use.

This retrospective cohort study linked data from St John New Zealand EMS electronic patient report forms (ePRFs) and computer aided dispatch (CAD) with mortality data from the New Zealand Ministry of Health. The observational study employed a quantitative approach and reviewed 60,640 cases of patients discharged-at-scene by paramedics from July 2016 to October 2017.

This study found that 59 patients died within one day: a mortality rate of 0.1%, 116 patients died within three days: a mortality rate of 0.2%, and 279 patients died within seven days of being discharged-at-scene: a mortality rate of 0.5%. These mortality rates are equivalent to reported rates of mortality in studies of discharge-at-scene in Australia and the United Kingdom. This study found that the eNTC was used in 36.8% of cases and using the eNTC was associated with reduced 7-day mortality (UOR 0.58; 95% CI, 0.45, 0.77; $p < 0.001$).

After controlling for confounding, three factors remained associated with reduced 7-day mortality after discharge-at-scene. These factors were: single-crew compared to non-

single-crew (AOR 0.46; 95% CI, 0.30, 0.72; $p = 0.001$), eNTC use compared to non-use (AOR 0.60; 95% CI, 0.45, 0.81; $p = 0.001$), and summer season compared to winter (AOR 0.60; 95% CI, 0.38, 0.91; $p = 0.026$).

Conversely, four variables remained associated with increased mortality. These were: older age ≥ 65 years compared to younger age (AOR 6.10; 95% CI, 4.27, 8.71; $p < 0.001$), more severe clinical status compared to less severe clinical status (AOR 3.50; 95% CI, 2.65, 4.61; $p < 0.001$), longer time on scene compared to shorter time on scene (AOR 2.08; 95% CI, 1.52, 2.85; $p < 0.001$) and male patient sex compared to female patient sex (AOR 1.57; 95% CI, 1.21, 2.04; $p = 0.001$). Patient ethnicity was determined not to have an association with mortality.

This research gives an understanding of the outcomes for patients discharged-at-scene by paramedics and can be used as a benchmark to enable improvements in clinical practice. To the best of our knowledge, this study is the first to explore the use of a checklist to improve outcomes of patients discharged-at-scene. An association between paramedic use of a checklist and improved patient safety is established. Low voluntary compliance with checklist use was observed: this supports making its use compulsory.

Keywords: EMS; Paramedic; Discharge-at-scene; Non-transport; Non-conveyance; Outcome; Safety; Mortality, Checklist; New Zealand,

Contents

List of Figures

List of Tables

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgments), nor material which, to a substantial extent has been submitted for the award of any degree or diploma of a university or other institution of higher learning.

Fraser Watson, 7th May 2021

Acknowledgements

The following financial assistance helped me complete this thesis: the 2018 Auckland University of Technology Post Graduate Scholarship and St John Professional Development support (2019). I am fortunate to have received these contributions.

I wish to express my deep respect and gratitude to my supervisory team: Dr Bronwyn Tunnage, Adjunct Professor Bridget Dicker and Dr Verity Todd. Your generosity, insight and gentle but persistent encouragement to organise content and polish style has been both invaluable and enjoyable.

For access to St John data, encryption, matching with Ministry of Health data, and warmly hosting a forlorn distance student during repeated visits to Auckland, my most grateful acknowledgements are due to the St John Clinical Audit and Research Team led by Adjunct Professor Bridget Dicker.

To Mr Tony Ward and the Auckland University of Technology Paramedicine Team I owe a debt of gratitude for generously accommodating me during visits to Auckland. To Liaison Librarian Drew South: my thanks for guiding the search strategy and navigating the perils of EndNote travelling libraries. My thanks to Dr Andy Swain for your authoritative review of the postgraduate research application. To Mr James Kendrick (then) chair of Tāhuhu, the Auckland University of Technology Mātauranga Māori Committee, the Auckland University of Technology Ethics Committee, and the New Zealand Ambulance Association: your support for this project is deeply appreciated.

For your encouragement and understanding I wish to thank my managers at St John; Kris Gagliardi, Johnny Mulheron, and Jon Moores. It has been a novel and humbling experience for me to receive this level of backing. I sincerely hope this thesis makes a positive impact on paramedic practice and goes some way to justify your faith in me.

Finally, a huge thank you to my wonderful family: my wife Lis, son Reuben and daughters Isobella and Charlotte. Your tolerance for the time I have spent tapping away at a keyboard in the study, instead of doing all the other things we could have done together as a family, is gratefully accepted.

There are no conflicts of interest to disclose.

Ethical and Locality Approval

Ethical approval for this research was sought from and granted by the Auckland University of Technology Ethics Committee (AUTEC). Approval was granted on 31 May 2018 with reference 18/200 (Appendix A).

Locality review and approval was sought from and granted by St John New Zealand. Approval was granted on 10 August 2018 (Appendix B).

Chapter 1 Introduction

1.1 Overview

This chapter will describe the role and practice of Emergency Medical Services (EMS) in broad terms and place New Zealand EMS in an international context. This chapter will then outline the way increasing calls for low-acuity cases have contributed to increased demand for EMS. A description is given of how EMS practice has changed in response to that demand, primarily by discharging more patients at scene instead of transporting them to hospital. The relationship between Emergency Department (ED) overcrowding and increased discharge-at-scene by paramedics is noted. A review of discharge-at-scene terminology follows and is accompanied by a discussion of the decision-making process. EMS policies and attitudes towards discharge-at-scene are explored. This leads to an evaluation of the limited understanding of the outcomes of paramedic practice, specifically the outcomes of discharge-at-scene. A lack of clinical tools to support discharge-at scene decision-making is identified. The research aims are then stated, the chapter is summarised, and an overview of the thesis structure is provided.

1.2 EMS in New Zealand

1.2.1 EMS overview

EMS provide pre-hospital care and transportation of the sick and injured. EMS are also described as ambulance services or paramedic services. EMS clinicians are known as ambulance officers, emergency medical technicians and paramedics. Multiple paramedic titles are in use including advanced paramedic, intensive care paramedic, critical care paramedic and extended care paramedic. There is little international consistency in the definitions and scope of practice associated with these titles. New Zealand EMS practice levels and equivalent terms are summarised in Figure 1.

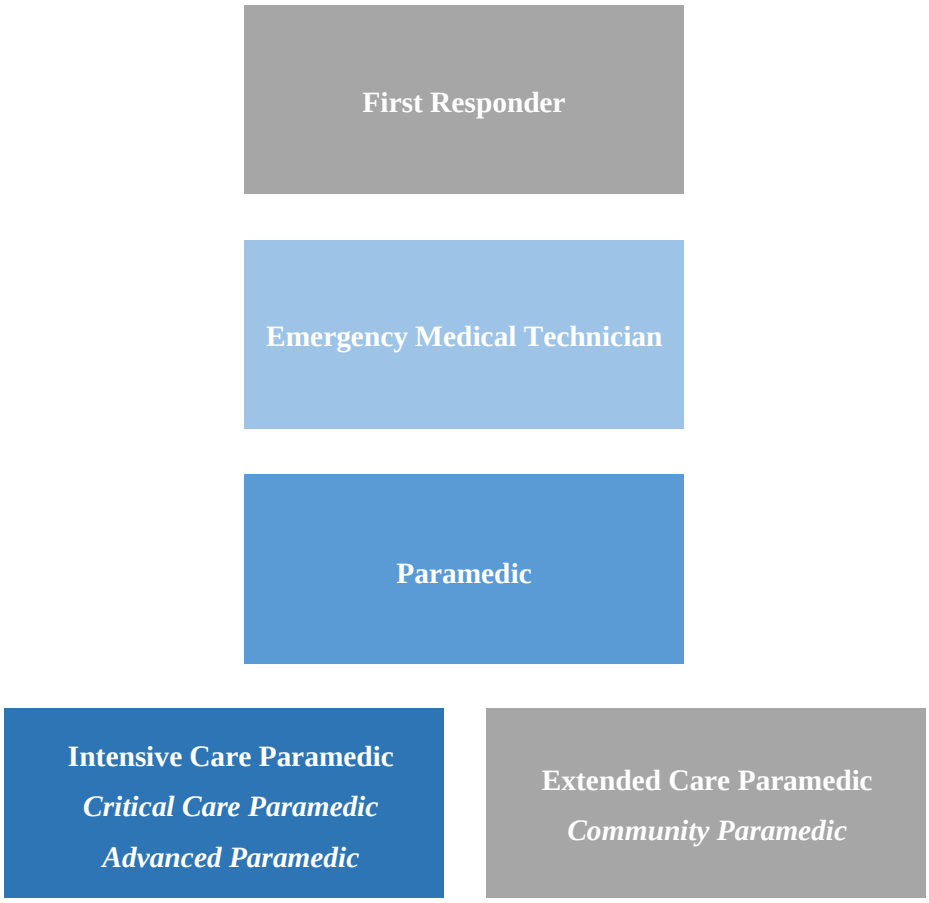

Figure 1. New Zealand EMS practice levels

Note: International equivalent terms are included in italics. Practice levels in grey boxes were not included in this study. Practice levels are ordered from entry level at top to most senior at bottom.

This study will use the over-arching term “paramedic” to refer to all types and practice levels of EMS clinicians, except for doctors or nurses. In contrast to many English-speaking countries, European EMS often employ doctors, nurses or a combination of paramedics and doctors or nurses. New Zealand EMS exclusively employ paramedics to provide clinical care. Doctors and nurses are not included because they have a distinct scope of practice and this study is focused on understanding the practice of New Zealand paramedics.

1.2.2 EMS and the New Zealand health system

Paramedics and EMS have not traditionally been considered part of the health system of New Zealand. Although regulation has long been proposed, and consultation began in earnest in 2016 (Ministry of Health, 2016), paramedics first registered as health professionals in 2021. Rather, paramedics were thought of as emergency service workers. Exempt from the scrutiny to which other health professionals are subject, paramedics did not feature in a wide-ranging review of New Zealand healthcare (Health Quality and Safety Commission, 2015). The slow movement towards registration for paramedics in New Zealand may be due in part to the low number of complaints about paramedics: at 0.4% this is the lowest rate of complaints per 1,000 practitioners of any health profession in New Zealand (Ministry of Health, 2016). Regardless of belated professional registration, New Zealand paramedics have a duty to ensure the rights of health service consumers are upheld (Health and Disability Commissioner, 2021).

1.2.3 Māori health outcome inequity

Māori (the indigenous peoples of New Zealand) are known to suffer inequitable health outcomes typical of ethnic minorities and indigenous peoples globally. Māori experience higher incidence and worse survival from all types of cancer (Gurney et al., 2019). Of relevance to EMS provision, Māori experience worse outcomes from out-of-hospital cardiac arrest (Dicker, Todd, et al., 2019). Against this background, it is possible that Māori also experience inequitable outcomes from EMS care for situations other than for out-of-hospital cardiac arrest such as discharge-at-scene.

1.2.4 New Zealand EMS providers

St John is the major EMS provider in New Zealand covering approximately 90% of the New Zealand population, providing EMS to approximately 4 million people (Beck et al., 2016; St John New Zealand, 2016a). Wellington Free Ambulance provides EMS to the remaining 10% of the New Zealand population. This study investigates the St John EMS system in New Zealand.

1.2.5 Requests for EMS in New Zealand

Most requests for EMS in New Zealand are received by a dedicated “111” emergency telephone line. Some requests for EMS are received via non-urgent telephone lines such as free-to-call 0800 numbers. All requests for EMS are processed in one of three New Zealand EMS communications centres by dedicated EMS call-handling staff using the

ProQA™ Advanced Medical Priority Dispatch System. Some requests for EMS are managed by clinical staff in EMS communications centres by telephone advice or referral to other services and no EMS unit is ever dispatched.

1.2.6 New Zealand EMS response

For requests resulting in dispatch of an EMS resource, an ambulance unit, usually with two paramedics, will respond. During the study period, and unlike EMS in other high-income countries, New Zealand St John EMS deployed ambulance units crewed with a single paramedic. Further, rapid response units (cars, not ambulances) crewed with a single paramedic are also a feature of New Zealand EMS responses.

Most patients attended by an EMS crew are transported, often to an ED. A minority of patients are discharged-at-scene instead of being transported. EMS providers have varying rates of discharge-at-scene. There is no consistency in how these rates are calculated or reported. Studies of EMS in high income countries report rates of discharge-at-scene in the general population between 12.7% to 21.4% (Carroll et al., 2015; Jensen et al., 2013; Knight et al., 2003; Schmidt et al., 2006; Tohira et al., 2016c). Rates of discharge-at-scene in New Zealand EMS are similar, trending upwards from 16.7% to 17% from 2015 to 2017 (G. Stewart, personal communication, December 1, 2020).

1.3 Increased demand for EMS

EMS in high-income countries have experienced a sustained surge in demand for decades (Lowthian, Cameron, et al., 2011). Demand for EMS response in New Zealand has increased significantly since 2001 (Swain et al., 2010). In the year ended 30 June 2007, St John paramedics had a face-to-face clinical interaction with 322,644 patients (St John New Zealand, 2007). Over the next decade this rose to 469,850 patients (St John New Zealand, 2017); an increase of more than 45%.

This rate of increase in EMS demand is consistent with international trends (Pittet et al., 2014) and is faster than can be attributed to a growing population (Lowthian, Cameron, et al., 2011). The two major drivers of increased EMS demand are an accelerating rate of calls for low-acuity problems and an aging population (Dwyer et al., 2018; Lowthian, Jolley, et al., 2011; Pittet et al., 2014). It is unclear why there should be an increased number of EMS calls for low-acuity problems. From a patient perspective, fear of possible adverse outcomes is identified as a common theme in low-acuity cases (van

Doorn et al., 2020). Primary care access limits such as reductions in after-hours general practitioner (GP) cover and fewer GPs may contribute to a switching of demand from doctors to paramedics (Pittet et al., 2014; Swain et al., 2010). Relatively low cost (Ting & Chang, 2006) and simplicity of access (Pittet et al., 2014) appear to lower the threshold for requesting EMS.

The proportion of the population over 65 years old has greatly increased in New Zealand, similar to high-income countries world-wide (Christensen et al., 2009). This aging population is strongly associated with increased EMS demand (Goldstein et al., 2015; Lowthian, Jolley, et al., 2011; Pittet et al., 2014). Demand for those aged > 85 years exceeds predictions based on demographic changes (Lowthian, Jolley, et al., 2011) and EMS demand by the elderly is forecast to continue growing (Aboagye-Sarfo et al., 2016). Elderly are increasingly living alone in the community, there is reduced societal capacity to care for elderly relatives, and more elderly are living with complex health problems (Lowthian, Cameron, et al., 2011). Combined with primary care access restrictions these factors can result in limited alternatives for accessing health care, especially out-of-hours, and may explain the increased EMS demand by the elderly (Lowthian, Jolley, et al., 2011).

1.4 EMS response to increased demand

In response to this change in demand EMS have evolved from being narrowly focused on emergencies into a health resource providing a variety of services (Durham et al., 2016; Lowthian, Cameron, et al., 2011). The most significant developments are enhanced EMS telephone triage and dispatch systems, the establishment of new EMS roles such as Extended Care Paramedics (Mason et al., 2007; Swain et al., 2010; Tohira et al., 2014) and an increased emphasis on paramedics in traditional EMS roles managing low-acuity presentations (Gray & Wardrope, 2007).

1.4.1 Telephone advice

Although some literature includes those patients diverted from ED via telephone advice within the discharged-at-scene group (O'Cathain et al., 2018), no face-to-face interaction with a paramedic has occurred. Instead, patients are either given health advice or referred to other health providers.

1.4.2 Extended care paramedics

The primary role of Extended Care Paramedics is to manage unplanned low-acuity presentations in the community. Extended Care Paramedics are more likely to work with an older population and spend more time on scene with the patient. They collaborate and communicate in a more integrated fashion with other health professionals to achieve high rates of patient satisfaction and low rates of transfer to ED compared to standard EMS crews. (Cooper & Grant, 2009; Swain et al., 2010).

1.4.3 Increased rate of discharge-at-scene by paramedics in traditional roles

The focus of this study is the way paramedics in traditional roles have adapted to increased low-acuity workload by discharging more patients at scene instead of transporting them to ED. Rates of transport to ED in England fell from 90% in 2000 to 58% in 2012 (Snooks et al., 2013). Current rates of transport to ED in New Zealand EMS are similar at 61.8% (Glen Stewart, personal communication, 2 December 2020). The broad trends in EMS disposition of patients since 2000 are summarised in Figure 2.

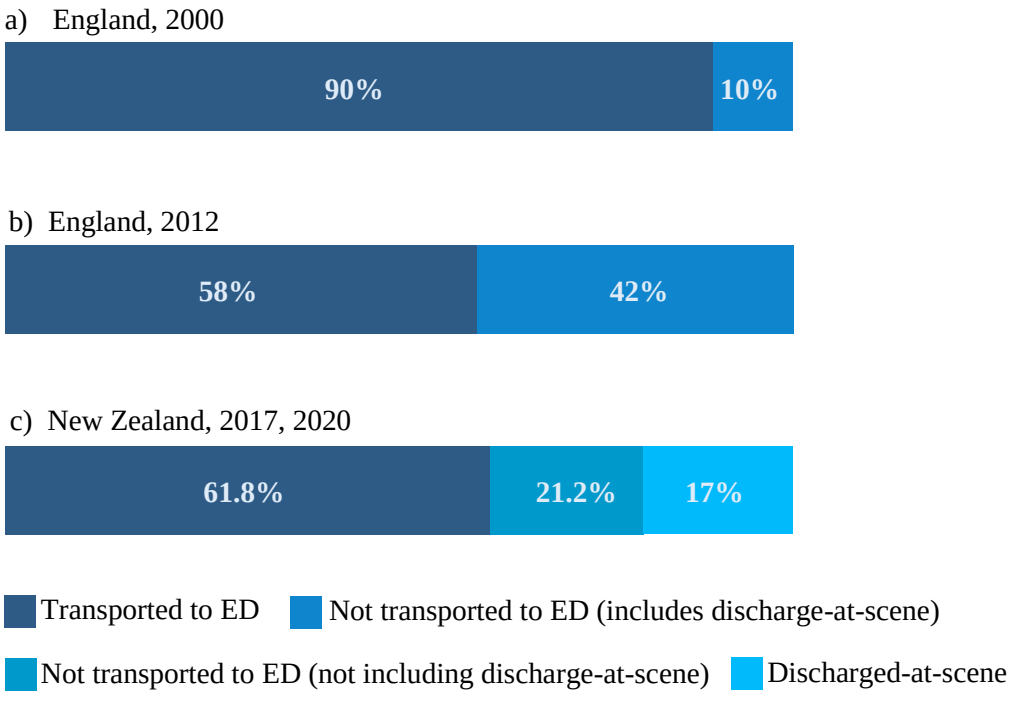

Figure 2. Change in EMS practice since 2000

Notes: a) Ambulance Service Summary Statistics, England: 2000 (Snooks et al., 2013), b) Ambulance Service Summary Statistics, England: 2012 (Snooks et al., 2013), c) St John New Zealand data: 2017, 2020.

1.5 Discharge-at-scene

The association between increased EMS demand and increased numbers of patients discharged-at-scene by paramedics is well documented (Ebben et al., 2017; Hoikka et al., 2017; Jensen et al., 2015; Lowthian, Cameron, et al., 2011). Calls to older patients are associated with increased rates of discharge-at-scene (Marks et al., 2002), particularly for elderly patients who have fallen (O'Cathain et al., 2018).

The most common low-acuity calls to EMS are for falls. Calls for higher acuity but easily reversible or transient situations include problems such as hypoglycaemia, seizures, and opioid overdoses. EMS providers have developed clinical guidelines for paramedics to support safe discharge-at-scene decisions in response to calls for these common specific problems. However, the safety of these guidelines has been questioned (Tohira et al., 2016a) and there is little guidance for paramedics when discharging undifferentiated low-acuity patients at scene.

1.6 Terminology

Discharge-at-scene is a relatively new term used to describe the process by which paramedics decide that a patient may be safely left in the community instead of being transported to ED (Ebben et al., 2017; O'Cathain et al., 2018; Tohira et al., 2016c). Other terms previously used included non-transport and non-conveyance.

Discharge-at-scene more accurately describes the clinical decision-making to end or de-escalate care during face-to-face interaction with patients. In comparison, terms hinging on the action of transport (or non-transport) are not sufficiently accurate in defining discharge-at-scene. This is because non-transport may include situations where no interaction occurs between paramedic and patient. Examples include calls where no patient is found and calls involving accidental medical alarm activations. Further, in a small number of cases paramedics will assess a patient in a public place, and then transport the patient to a home address. Here transport has occurred, but the patients' care has been ended, not transferred: the paramedic has decided to discharge the patient.

There are also instances when the patient is transported to a medical facility other than an ED, such as to a GP clinic, a hospice, or a specialised secondary care unit such as a stroke treatment centre. In these situations there is wide variation in patient acuity and expected outcome and it is not clear that they can be meaningfully grouped with patients discharged at scene by a paramedic (O'Cathain et al., 2018).

1.7 ED overcrowding

Overcrowding of EDs is a driver of paramedic discharge-at-scene. Emergency department overcrowding is a widespread phenomenon in the health systems of high-income countries and is proportional to the rise in demand for EMS responses (Lowthian, Cameron, et al., 2011; Swain et al., 2010). Emergency department overcrowding is associated with poor patient outcomes and health system inefficiencies (Lowthian, Curtis, et al., 2011; Richardson & Mountain, 2009).

Attempts to reduce unnecessary patient presentations to ED, including low-acuity patients transported to ED by paramedics, have become a popular target for emergency health system transformation (Villarreal et al., 2017). However, the contribution low-acuity patients make to ED overcrowding is overstated (Richardson & Mountain, 2009; Schull et al., 2007). Anticipated performance gains in ED are not delivered by simple process changes such as diverting low-acuity patients to non-ED community pathways (Kirkland et al., 2019; Manley et al., 2016). Evidence to support diversion of low-acuity patients away from ED as a strategy to manage ED overcrowding is lacking (Kirkland et al., 2019). Regardless, the perception that paramedics transport an unhelpful volume of low-acuity cases to ED is pervasive (Fraess-Phillips, 2016; Lowthian, Curtis, et al., 2011) and has become a driver for increased discharge-at-scene by paramedics (Finn et al., 2013; Swain et al., 2010).

1.8 Patient acuity

Discharge-at-scene decisions are often, but not exclusively, associated with low patient acuity. Higher acuity discharge-at-scene situations include end-of-life and palliative care cases, where patient death is expected at some point. Higher acuity discharge-at-scene situations also include easily reversible problems such as hypoglycaemia and transient problems such as seizures.

High-acuity cases such as frail residents of aged care facilities have emerged as a cohort for whom the value of transport to ED is questioned (Dwyer et al., 2014). For these patients the frequency and severity of complications associated with hospital care is raised (Kruse et al., 2013; Quach et al., 2012) and mortality is elevated (Arendts et al., 2012). For the very frail with multiple comorbidities, the implication is that transfer to ED for in-hospital care is costly, futile, unpleasant and not in the best interests of most such patients (Dwyer et al., 2014).

1.9 Decision complexity

Decision-making for the group of patients discharged-at-scene is relatively more complex for paramedics than might be expected (O'Hara et al., 2015; Oosterwold et al., 2018; Zorab et al., 2015). Making multiple clinical and operational decisions in a short time and in relatively austere and often adverse environments is a hallmark of contemporary paramedic practice (O'Hara et al., 2015; Simpson et al., 2017). However, patients are requesting EMS for increasingly complex medical problems and this complexity inhibits discharge-at-scene (Snooks et al., 2005). Discharge-at-scene decisions often require paramedics' clinical judgement to be exercised in the absence of access to the patients' medical information (Zorab et al., 2015). These factors combine to present paramedics with decisions involving a degree of intricacy not found in relatively more straightforward transfers to ED.

Paramedic specific factors in discharge-at-scene decision-making include the paramedics' degree of clinical experience, level of education and extent to which they embrace a holistic approach to healthcare. Less experience, lower levels of education and a narrow approach to care are associated with lower rates of discharge-at-scene (Sheffield et al., 2016). Conversely, paramedics report that with increased experience they felt more confident discharging patients at scene (Snooks et al., 2005).

The relationship of clinical guidelines to paramedic discharge-at-scene decision-making is nuanced. Paramedics have varying levels of adherence to guidelines; particularly when guidelines do not address the needs of patients with complex medical problems who do not need immediate transfer to ED (Sheffield et al., 2016). The interplay between discharge-at-scene and clinical guidelines, clinical decision support tools and checklists is discussed later in this chapter.

1.10 Risk versus benefit

A risk-benefit assessment sits at the heart of the discharge-at-scene decision-making process. If serious illness is missed the fundamental risk to the patient is an adverse or even a disastrous outcome. Adverse patient outcomes include additional contacts with health providers, delayed access to definitive care, preventable admission to hospital, prolonged length of stay in hospital and avoidable intensive care unit admission. In extreme cases, death may occur. In situations where the patient has a poor outcome the risks to the paramedic include censure, limits on professional registration, loss of employment or litigation (Ramgopal et al., 2018).

Tailoring care to maximise benefits to the patient is pivotal to guiding discharge-at-scene decisions (Villarreal et al., 2017). Patient-centred benefits of clinically appropriate discharge-at-scene include enabling patients to stay in their own home, stay close to support networks and avoid costs such as loss of time, unnecessary travel and disruption to family care arrangements. Greater distance to ED is associated with increased rates of discharge-at-scene, particularly out-of-hours (Hoikka et al., 2017). Avoiding medically unnecessary ED attendance avoids subjecting patients to risks such as unwarranted invasive investigations and exposure to infectious disease. The elderly experience disproportionate rates of adverse outcomes associated with ED attendance (Dwyer et al., 2014).

1.11 Who is making the decision?

The literature is not unanimous on whether a patient who is documented to have refused care should be considered to have been discharged-at-scene by a paramedic. At face value, patient refusal of care implies the decision has been made by the patient (Knight et al., 2003), and this should exclude refusals from being grouped with patients discharged-at-scene by paramedics. However, there is evidence that paramedics encourage patient refusals to avoid transport, especially in EMS systems where transport to ED is compulsory unless refused (Shaw et al., 2006). This behaviour casts doubt over the validity of instances where the patient is recorded as refusing care. A review of written electronic patient report forms (ePRFs) for refusal to travel cases found the term “refusal” to be misleading, as on inspection less than 10% of the cases met that definition (Shaw et al., 2006). This uncertainty is intensified when considering that the gender of the paramedic may have a significant effect on the rate of refusals. Male-only crews were found to have more than four times the rate of refusals than female-only or mixed gender paramedic crews in a US study (Waldron et al., 2012). This suggests undue paramedic influence on what is ostensibly a patient decision.

Even thinking of the discharge decision-making in a simple binary way may be erroneous; shared decision-making between patient and paramedic is a third potential category (Persse et al., 2002; Schmidt et al., 2006). Shared decision-making is gaining traction as a valid decision-model in acute settings such as in EDs (Hess et al., 2015; Probst et al., 2017) but it is not yet clear how applicable it is to the discharge-at-scene decision-making by paramedics. Discharge-at-scene is thus sensitive to patient and

paramedic interests and not easily split into paramedic-initiated or patient-refusal categories (Ebben et al., 2017).

There is a power imbalance inherent in the relationship between a patient and any health professional, including paramedics. Patients are relatively vulnerable because they are sick or injured and typically are inexperienced navigators of the health system. The effect of this imbalance on the autonomy of patient refusals of paramedic care (including transport) is unknown and probably worthy of further study. In summary, these factors are judged to weigh in favour of considering patient refusals of transport as equivalent to being discharged-at-scene by paramedic in this study.

1.12 EMS policy and clinical guidance

Paramedic licence to discharge patients at the scene varies widely across EMS providers. Variation between EMS providers is multifactorial but appears not to be informed by objective data on the safety of discharge-at-scene. Rather, variances stem from differences in levels of deployment of extended care paramedics and differing organisational attitudes toward perceived risks and benefits of discharge-at-scene (O'Cathain et al., 2018; Oosterwold et al., 2018).

United States EMS providers operate within a governance framework which has traditionally discouraged or prohibited independent paramedic discharge-at-scene. This is primarily due to funding constraints (where funding is contingent on transport) and a litigious environment (Deziel, 2017; Knapp et al., 2009). In the United States, ED doctors continue to insist that the default option for every patient accessing EMS for acute, undifferentiated problems should be transport to an ED (American College of Emergency Physicians, 2018). This is at odds with the position of EMS authorities who seem to be moving towards a position of increased license for EMS provider-initiated discharge -at-scene (National Association of EMS Physicians, 2011). In comparison, English and Australian EMS providers have moved away from mandating transport for most patients and now enable paramedics to discharge-at-scene with varying degrees of autonomy (Snooks et al., 2005; Snooks et al., 2013).

New Zealand paramedics in contrast have traditionally enjoyed a high degree of autonomy to discharge patients-at-scene. Previously this has occurred without formal clinical guidance. However, since 2007, New Zealand EMS clinical guidelines have gradually added content aimed at supporting safe discharge-at-scene decisions (St John

Clinical Management Group, 2007). An example which illustrates the magnitude of the change in clinical guidance is the approach to respiratory problems. The 2016 New Zealand EMS clinical guidelines (National Ambulance Sector Clinical Working Group, 2016) contain guidance on discharging patients at scene with (amongst other problems) less-severe presentations of asthma and chronic obstructive respiratory disease. In the 1999 edition of the clinical guidelines however, asthma and chronic obstructive respiratory disease were listed in the section of immediately life-threatening problems requiring immediate transfer to hospital (New Zealand Ambulance Education Council Clinical Advisory Group, 1999). Only 10% of EMS workload is at this severe end of the spectrum though (Turner, 2010) and it is in dealing with the other 90% of lower-acuity presentations that paramedic discharge-at-scene has evolved.

1.13 Outcomes of discharge-at-scene

In general, the patient outcomes of paramedic clinical practice are poorly understood. Most paramedic-relevant research about patient outcomes focuses on high-acuity situations such as the outcomes of out-of-hospital cardiac arrest (Murphy et al., 2016). The outcomes of low-acuity patients discharged-at-scene is less well researched (Ebben et al., 2017). The competence of paramedics to make safe discharge-at-scene decisions has been repeatedly questioned (Fraess-Phillips, 2016; Hauswald, 2002; Neeki et al., 2016; Tohira et al., 2016c; Tohira et al., 2014).

Traditional EMS performance measures focus almost entirely on response times for urgent cases. The value of these traditional performance measures in improving ambulance service delivery and patient outcomes has been challenged (Murphy et al., 2016). A narrow focus on response times comes at the cost of ignoring patient outcomes and may not adequately cover the broadening scope of EMS provision (Coster et al., 2018; Durham et al., 2016). The outcomes of patients discharged-at-scene are not a current New Zealand EMS performance measure (National Ambulance Sector Office, 2018).

1.13.1 Safety for specific patient groups

There is some evidence to support the safety of discharge-at-scene for patients with low-acuity or easily reversible problems such as hypoglycaemia (Cain et al., 2003), opioid overdose (Heyerdahl et al., 2008; Levine et al., 2016; Rudolph et al., 2011; Stam et al., 2018; Vilke et al., 2003), and falls (Leggatt et al., 2017; Mikolaizak et al., 2017; Snooks et al., 2017; Snooks et al., 2014). However, the safety of paramedic discharge-

at-scene for the undifferentiated general population requesting EMS is essentially unknown (Ebben et al., 2017; Tohira et al., 2016b; Tohira et al., 2016c).

1.13.2 Inconsistent outcome reporting

The literature reports an extensive variety of parameters of paramedic discharge-at-scene but in general, patient outcomes are not well reported (Jensen et al., 2015; Mikolaizak et al., 2013). Further, there is no consensus on which outcomes are the most important to measure, and no consistency in how these outcomes are measured or reported (Ebben et al., 2017; Jensen et al., 2015).

Where outcomes of discharge-at-scene are reported, they are broadly grouped into service utilisation and clinical safety outcomes. Service utilisation measures include further unplanned use of EMS (repeat calls) and various EMS process measurements, but it is not clear that either of these equate with an actual adverse event or adverse patient outcome. Clinical safety outcomes include subsequent healthcare utilisation events and mortality.

1.13.3 Repeat calls to EMS

Measuring repeat attendances of EMS to a patient seems to have some value in identifying potential for an adverse event (Howard et al., 2017). However unplanned repeat EMS attendances do not necessarily indicate an adverse outcome for the patient (Jensen et al., 2013; Pekanoja et al., 2018). Additionally, there is no agreement on the time elapsed between an index case and subsequent case which indicates the two cases are related. Repeat access to EMS was measured from 24 hours after index case up to seven days for the general population, and up to one year for some specific populations such as the elderly, and those who had fallen (Ebben et al., 2017; Mikolaizak et al., 2013; Tohira et al., 2016c).

1.13.4 EMS process measurements

EMS process measurements relevant to discharge-at-scene include case cycle time and time on scene. Case cycle time is the time an EMS unit is committed to a case. This is usually defined as time from when an EMS unit is dispatched to when it becomes clear and available for further tasking, either at ED after transport or at the scene after discharge-at-scene. EMS providers may see potential efficiencies in reducing case cycle times and case scene times and usually have easy access to this data. However, service utilisation measurements such as prolonged scene time in the setting of discharge-at-

scene cannot be construed as an adverse outcome for the patient. On the contrary, unlike critically ill patients (Brown et al., 2016) longer scene times may be associated with higher quality paramedic care in discharge-at-scene cases (Snooks et al., 2004).

1.13.5 Subsequent healthcare utilisation

Similarly, there is no agreement on whether hospital admission, compared to ED attendance, is more indicative of an adverse clinical outcome after paramedic discharge-at-scene. Hospital length of stay was infrequently measured (Ebben et al., 2017; Jensen et al., 2015). Quality-adjusted life years (QALYs) are measured even less frequently (Dixon et al., 2009) and the QALY is not universally accepted as an ideal health outcome measure (Pettitt et al., 2016).

A subset of hospital admissions are associated with highly preventable adverse incidents; these result in an average 9-day prolonged length of stay, and 20% of those preventable adverse events occurred outside the hospital (Davis et al., 2001). However, it is unclear what contribution paramedic discharge-at-scene decisions make to the number of preventable out-of-hospital adverse events and implying a causal association is not straightforward in this situation.

Events after discharge-at-scene which may more objectively indicate an adverse outcome include intensive care unit admission and mortality. Patient event pathways are complex (Coster et al., 2019) and it is difficult to determine that subsequent prolonged length of stay or intensive care unit admission have directly resulted from paramedic discharge-at-scene decisions. In comparison, death is an extreme and concrete outcome unlikely to be affected by bias in retrospective studies (Lamantia et al., 2013). Mortality thus appears to be a superior indicator of adverse outcome after discharge-at-scene.

1.13.6 Mortality as an outcome of discharge-at-scene

Mortality may be a straightforward quantitative assessment of patient outcome associated with discharge-at-scene but is unevenly reported (Fisher et al., 2015; Yardley & Donaldson, 2016). Poor patient outcome after discharge-at-scene is overlooked as a source of potential adverse patient outcomes in reviews of adverse events in EMS provision (Hagiwara et al., 2019; Patterson et al., 2012). Unexpected deaths in a health context have long been the focus of mortality review committees. A 2013 review of the New Zealand mortality review process did not make any mention of paramedics or EMS (Bellett et al., 2013) but did note an overarching scope for mortality review which

included all health related unexpected death. Mortality after discharge-at-scene would appear to meet that definition at face value.

Mortality after discharge-at-scene did not merit inclusion in performance benchmarking by North American EMS industry leaders (Myers et al., 2008) nor did it feature in a more recent review of North American EMS quality improvement programs (Redlener et al., 2018). Mortality is simply not expected to be an outcome associated with low-acuity primary care (Langabeer et al., 2016).

1.13.7 When to measure mortality?

There is no agreement on what constitutes a suitable time-lag between the index event (discharge-at-scene) and outcome (death) to imply an association (Coster et al., 2019; Ebben et al., 2017; Tohira et al., 2016c). Although a very short window, such as less than 24 hours, suggests a stronger correlation between events, it may be so short that no deaths have yet occurred (Coster et al., 2019). Conversely some studies report death as much as eight months after the index event (Staudenmayer et al., 2012) at which time the background rate of mortality in the general population may have a greater effect on outcome than any paramedic input or lack of input. Recent higher quality studies of discharge-at-scene have reported mortality at 1-, 3- and 7-days to enable comparison (Coster et al., 2019; Tohira et al., 2016c).

1.14 Non-transport checklist

Since 2016, St John New Zealand paramedics have used an electronic patient report form (ePRF) to record patient and treatment details (St John New Zealand, 2015). At that time, the New Zealand EMS clinical guidelines contained a non-transport checklist which was developed to support safe discharge-at-scene decisions in the general population. Non-transport checklist use was required in every discharge-at-scene case (National Ambulance Sector Clinical Working Group, 2013, 2016). The ePRF included an electronic version of the non-transport checklist (the eNTC) as a method to record that the non-transport checklist had been completed.

The non-transport checklist included six positive statements to be confirmed before a paramedic decided to discharge a patient at the scene. Confirmation of all six statements indicates a lower risk from discharge-at-scene. The statements are:

1. The patient has been fully assessed including a set of vital signs and appropriate investigations.

2. No vital signs (excluding temperature) are significantly abnormal.
3. Serious illness or injury has been reasonably excluded.
4. No red flags requiring transport to ED are present.
5. The patient is seen to mobilise (when able to normally do so), noting that if the patient is unable to mobilise there must be a minor or long-standing condition preventing this.
6. The patient and/or caregivers have been given a verbal and written explanation of when to seek further clinical advice.

In this checklist "red flags" refer to items which are worrying indicators of potentially serious problems relevant to specific clinical situations. The red flag items are listed in several flag tables in the clinical practice guidelines and ePRF. The red flags and flag tables cover various medical problems such as headache and vertigo. Detail of the red flags and the flag tables are outside the scope of this study. For the purposes of this study the eNTC is considered a simple clinical decision support tool suitable for the general population.

The contents of the checklist are derived from review of trends in adverse incidents associated with discharge-at-scene and the clinical gestalt of the authors (National Ambulance Sector Clinical Working Group, 2013, 2016). The eNTC is thus a collection of clinical and non-clinical items that the New Zealand EMS clinical governors considered to be aligned with prudent clinical practice prior to discharging a patient at scene. Although checklists are known to reduce medical error (Chen et al., 2016) the effectiveness of the eNTC is not validated by objective data.

It is expected that checklist use would improve adherence to clinical guidelines (Kerner et al., 2017). However, an internal St John audit found that eNTC use was recorded in only 25% of candidate cases (Barker, 2016). Paramedic documentation and compliance with clinical guidance, particularly in discharge-at-scene cases, is known to be imperfect (Gray & Wardrope, 2007; Porter et al., 2008). Consequently, St John made the use of the eNTC compulsory through ePRF software updates in December 2017.

The reasons for this low rate of procedural compliance are not understood. It is possible that a disconnect between the act of discharging a patient at scene and the outcome of that decision explains low paramedic use of the eNTC. Further, it is not known if this lower than anticipated frequency of eNTC use was representative of its use over time by

paramedics. In the period from that audit in July 2016, to when its use became compulsory in December 2017, St John communicated a reminder to use the eNTC on 28 November 2016 (St John New Zealand, 2016b). Consequently, paramedics may have used eNTC more frequently over time.

In summary, the frequency of eNTC use (until made compulsory) is unknown and effectiveness of the eNTC in reducing adverse outcomes from discharge-at-scene remains unproven.

1.15 Study aim

The aim of this study is to establish the mortality of patients discharged-at-scene by paramedics in New Zealand and investigate any association between using the eNTC (the exposure) and mortality (the outcome). However, frequency of eNTC use and factors influencing eNTC use are also unknown. While the intent of the eNTC is to reduce the rate of adverse events associated with discharge-at-scene, there is currently no evidence for any protective effect. Therefore, it cannot be assumed that eNTC use is associated with either a protective or a harmful effect on mortality rates.

It may seem counter-intuitive that eNTC use would be associated with increased mortality in the population discharged-at-scene. However, the motivations for a paramedic to use the eNTC are undetermined. It may be that eNTC use is a feature of diligent paramedic practice more likely to be associated with lower rates of adverse events including 7-day mortality. Conversely, paramedics may have used eNTC selectively in clinical situations they considered high-risk, and thus the associated rate of 7-day mortality may be higher.

1.15.1 Hypothesis

It is not clear there is any association between use of the eNTC (the exposure) and 7-day mortality (the outcome) in the general population discharged-at-scene by paramedics in New Zealand. Thus, the null hypothesis is “that there is no association between eNTC use and mortality after discharge-at-scene”. Inconsistent application of the eNTC by paramedics (possibly because of perceived clinical risk) may also be a source of selection bias. Thus, the non-directional alternative hypothesis, that “eNTC is associated with seven-day mortality rates of patients discharged-at-scene by paramedics in New Zealand”, will be investigated.

1.15.2 Research questions

Consequently, the research questions are:

a) What was the 1-, 3- and 7-day mortality rate of patients discharged-at-scene by paramedics in New Zealand?
b) How often was eNTC used to support discharge-at-scene?
c) Was there any association between eNTC use and 7-day mortality in patients discharged-at-scene?
d) What factors (other than eNTC use) are associated with 7-day mortality after discharge-at-scene?
e) What factors are associated with eNTC use?

1.16 Summary and thesis structure

This chapter has broadly described EMS systems and trends of increasing demand for EMS in high-income countries. EMS in New Zealand has been placed in this context. The traditional EMS model where most patients could expect transport to ED is being abandoned in the context of rising low-acuity demand. A new EMS model is emerging which enables paramedics to better match care to individual patient circumstances, resulting in larger numbers of patients discharged-at-scene. However, the safety of this deviation from conventional EMS practice is not supported by evidence. There is no real understanding of the outcomes of patients discharged-at-scene. The effectiveness of clinical decision support tools such as the eNTC is unknown.

The aim of this study is to establish the mortality of patients discharged-at-scene by paramedics in New Zealand and investigate any association between using the eNTC (the exposure) and mortality (the outcome). No prediction regarding patient outcomes is made. The null hypothesis is that eNTC has no association with 7-day mortality after discharge-at-scene. The alternative hypothesis is that eNTC is associated with 7-day mortality after discharge-at-scene. However, no prediction regarding the direction of that effect is made: a non-directional alternative hypothesis is adopted.

Chapter 2 will describe a semi-structured review of the literature designed to identify studies reporting mortality outcome after paramedic discharge-at-scene and use of clinical tools to support discharge-at-scene. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) methodology

(Shamseer et al., 2015). The results of the literature review are discussed and gaps in current knowledge identified.

Chapter 3 details the research methods employed to investigate the data. The research design including setting, participants, variables, mitigation of bias and statistical approach are reported in line with the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines (Vandenbroucke et al., 2007).

Chapter 4 reports the main results from the study including 1-, 3- and 7-day mortality after discharge-at-scene, rate of eNTC use, association between eNTC use and 7-day mortality, and variables associated with 7-day mortality and eNTC use. Results are reported in line with STROBE guidelines.

Chapter 5 contains a discussion of the results. The effectiveness in answering the research questions, limitations of the study, external validity (generalisability) and potential impact on practice are addressed. Suggestions for further research are made.

Chapter 6 summarises, delivers final statements and a conclusion. Supporting material is presented in the appendices and the overall thesis structure is outlined in Figure 3.

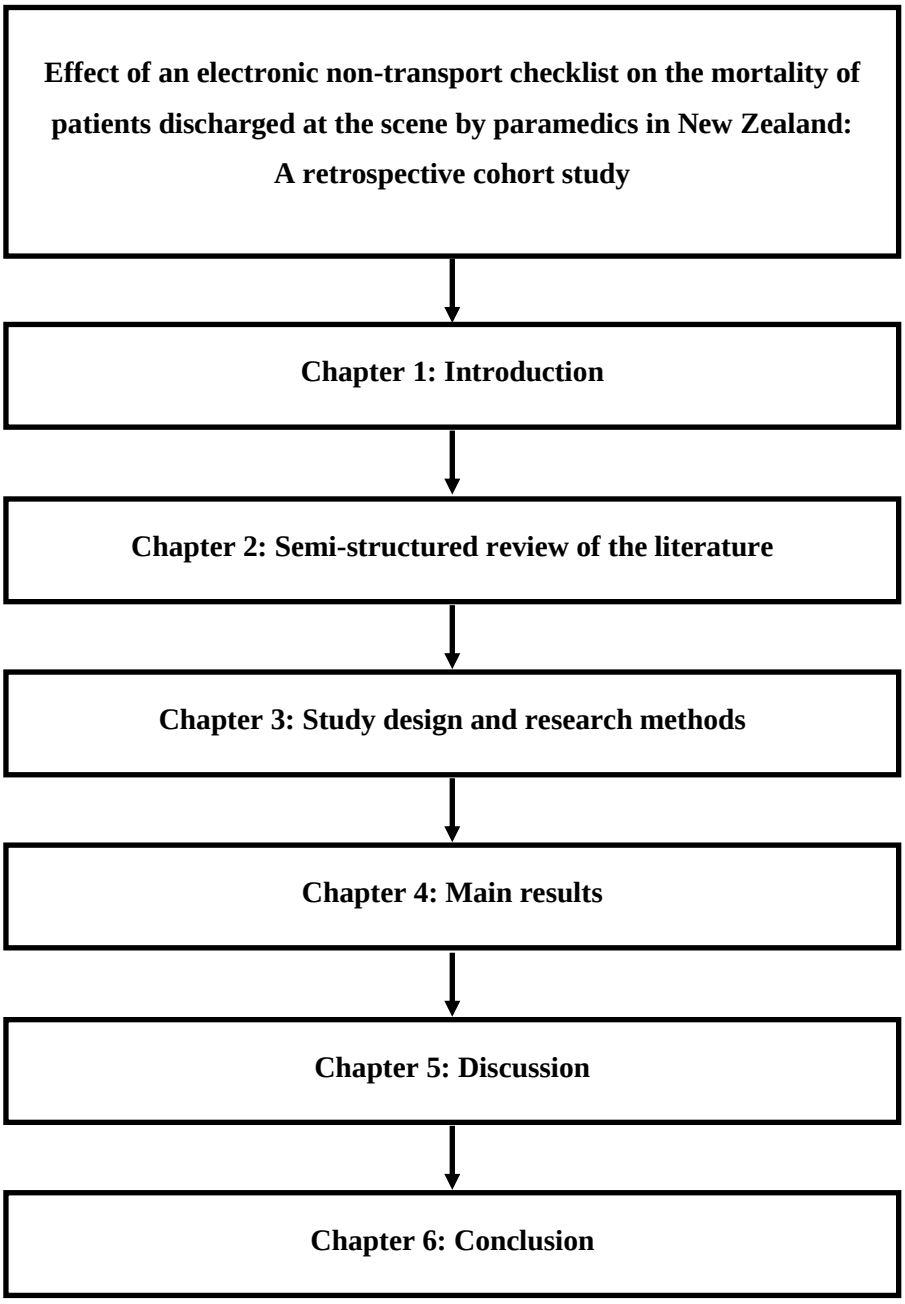

Figure 3. Thesis structure

Chapter 2 Literature review

2.1 Introduction

This chapter will review the literature which reports mortality after paramedic discharge of patients at scene and paramedic use of clinical tools to support discharge-at-scene. A systematic review methodology to identify studies reporting patient mortality after discharge-at-scene is detailed and the results are discussed.

None of the studies identified in the systematic review of mortality reported the use of a checklist to support discharge-at-scene. Therefore, a discussion of the literature reporting paramedic use of checklists in general, clinical tools other than checklists to support discharge-at-scene and non-paramedic use of clinical tools to support discharge is provided. These other clinical tools include clinical guidelines and early warning scores (EWS).

2.2 Literature review search strategy

A semi-structured search of the literature informed by the PRISMA-P methodology (Shamseer et al., 2015) was undertaken on 10 January 2020. The search was performed to identify studies with the following participant, intervention, comparator, and outcome (PICO) characteristics:

- **Participants**: Any patient cohort discharged at scene by paramedics.
- **Intervention**: Discharge-at-scene by paramedic
- **Comparator**: Not applicable
- **Outcome**: Mortality reported within one month of discharge-at-scene

Scopus, Emcare and CINAHL Complete via OVID, and Medline via EBSCO were searched. Assistance devising the search strategy was received from the Auckland University of Technology Health Sciences librarian. The search used the following terms and appropriate synonyms: “discharge-at-scene”, “refusal of care”, “refusal of transport”, “non-transport”, “non-conveyance”, “paramedic”, “emergency medical service”, “pre-hospital”, “out-of-hospital”, “mortality”, “death” and “outcome”. Studies of any methodology were included. Secondary analyses of data (such as systematic reviews) were excluded. Results were limited to studies published after 1 January 2000 and in the English language. The search was most recently performed on 21 September

2020. Older studies were excluded due to the previously described extent of change in paramedic service delivery. No limit by patient age was applied.

Article titles and some abstracts were reviewed for relevance. Bibliographies of included studies and systematic reviews were screened for additional relevant studies. Studies with high loss to follow-up were excluded from review. Studies where the discharge decision had been made by or in consultation with a doctor were excluded because these studies do not add anything to what is known about the outcomes of decisions made independently by paramedics. Studies where the EMS clinicians were health care practitioners (such as doctors or nurses) and not paramedics were excluded for the same reason. Studies reporting mortality after one month were excluded because of the difficulty confirming an association between discharge and mortality with increasing time. The literature review process is summarised in Figure 4.

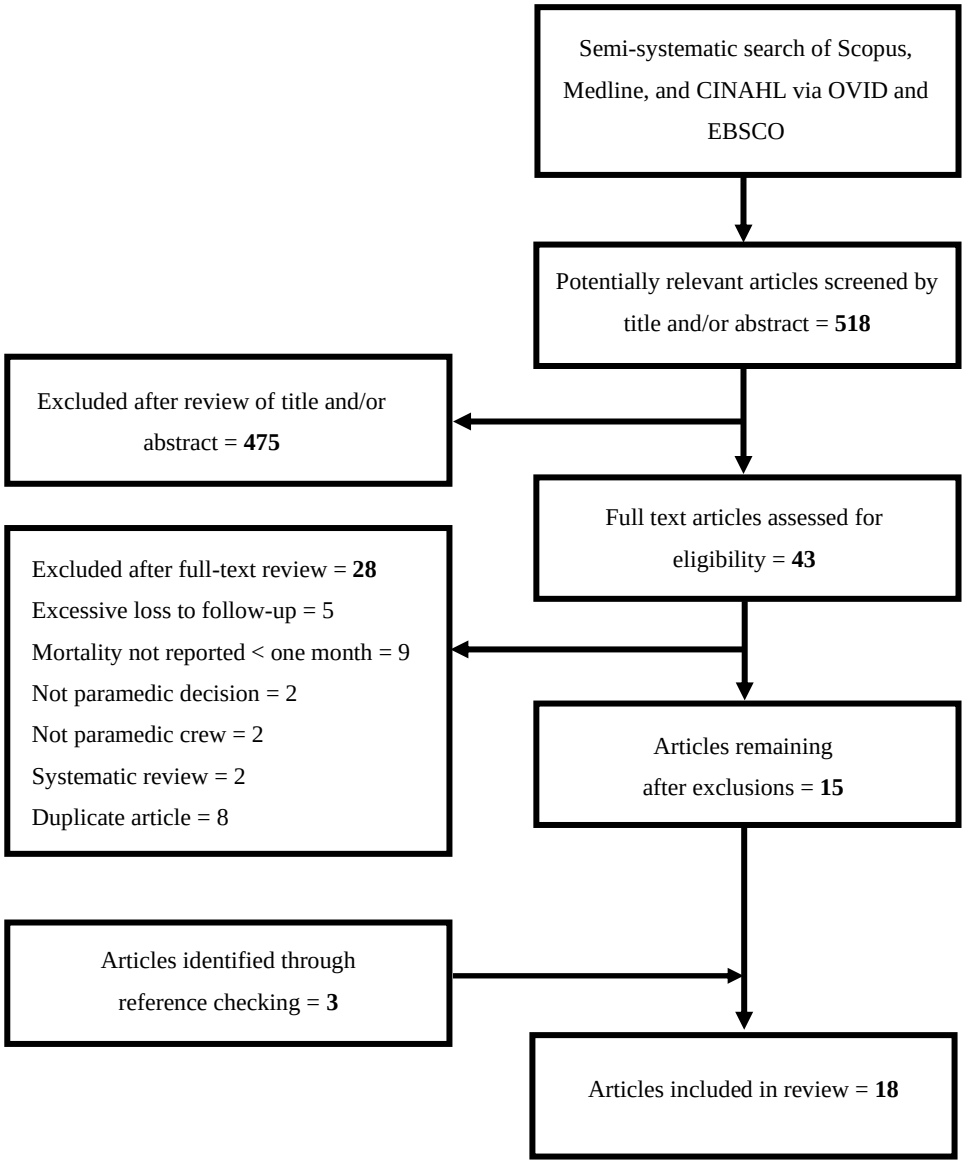

Figure 4. PRISMA-P flowchart for literature review of mortality

2.3 Literature review results

Data collected from the studies included the population description, date, size, and mortality. No attempt was made to quantitatively synthesise results from the included studies due to study heterogeneity. Eighteen studies reporting mortality after discharge-at-scene by paramedic were included and their results are summarised in Table 1.

2.4 Discussion of literature review results

Few studies reported mortality in the general population after discharge-at-scene. Review of studies reporting mortality in specific patient groups such as opioid overdose and hypoglycaemia revealed widely varying methods and mortality rates. Mortality rates are reported in Table 1. No attempt to analyse these results was made due to their heterogenous methodology and low generalisability to the undifferentiated population discharged-at-scene by paramedics. Eight studies reported mortality at seven days after discharge-at-scene by paramedic (see Table 1).

Three studies (Carroll et al., 2015; Coster et al., 2019; Tohira et al., 2016c) reported mortality from a large group of the general population discharged-at-scene by paramedics. These studies are now discussed in more depth and general themes are explored.

2.4.1 Australian data linkage study

A large Australian study designed to link EMS and health system data included 334,559 patients discharged-at-scene by paramedics and reported a 7-day mortality rate of 0.3% (Carroll et al., 2015). This finding sits in a paper which was not aimed at investigating discharge-at-scene mortality per se, rather it was focused on establishing data-linkage methodology to support research of paramedic practice. Inclusion and exclusion criteria were not elaborated upon other than noting that patients deceased at scene were not included. Consequently, the mortality data was not presented as a key finding, subject to any statistical analysis or further discussed by the authors.

Despite these methodological limitations, the study is included in this literature review due to its sheer size and relevance. This data is not referenced by the other studies reporting mortality after discharge at scene from the general population. It is unclear whether these other investigators (Coster et al., 2019; Tohira et al., 2016c) intentionally excluded this earlier study or were unaware of the relevant data it contained. A recent systematic review of patient outcomes after discharge-at-scene (Yeung et al., 2019) also

omitted reference to the findings from Carroll et al. (2015).This hints at the limitations of literature search strategies for the nascent health discipline of paramedicine (Olaussen et al., 2017). Although not referenced by other key studies, the 7-day mortality of 0.3% reported by Carroll et al. (2015) is less than the 0.5% mortality reported by Coster et al. (2019) or Tohira et al. (2016c) and is derived from a much larger cohort of patients so cannot be ignored.

2.4.2 UK data linkage study

Although finding similar 7-day mortality rates, Coster et al. (2019) and Tohira et al. (2016c) reached differing conclusions about the safety and appropriateness of discharge-at-scene by paramedics. Coster et al. (2019) reviewed 42,796 patients discharged-at-scene by an English EMS provider in 2013 and recorded 229 deaths: a 7-day mortality rate of 0.5%. The authors took a balanced approach to this finding. Coster et al. (2019) stated that deaths were an infrequent event associated with discharge-at-scene and recommended that such deaths could be further investigated for learning and quality improvement.

2.4.3 Australian discharge-at-scene versus discharge from ED study

Tohira et al. (2016c) compared the outcomes of 11,096 patients discharged-at-scene by paramedics with the outcomes of 27,197 patients transported by paramedics to ED and then discharged from ED. The study was completed during 2013 in Perth, Western Australia. The reported 7-day mortality rate of patients discharged-at-scene by paramedics in that study was 0.5% (Tohira et al., 2016c). Although identical to the 0.5% 7-day mortality rate found by Coster et al. (2019) this rate compared unfavourably to the 0.3% 7-day mortality rate of patients in the other arm of the study who were discharged from ED by doctors. The authors concluded that the current paramedic practice of discharge-at-scene is unsafe. However, factors limiting generalisability of these findings comprise:

- Inclusion of terminally ill patients in the discharge-at-scene arm
- High loss to follow-up in the discharge-at-scene arm and
- Unclear value in comparing paramedics with doctors.

These factors are now discussed in the following sections.

Table 1. Literature review results: Studies reporting mortality after discharge-at-scene

Study		Crude mortality: %, (number of cases)				
First author, date published, study location, study period (if reported)	**Study size, (population characteristics)**	**1 day**	**2-3 days**	**7 days**	**14 days**	**1 month**
Booley, 2015 South Africa	**110** (Hypoglycaemia)			19% (21**)**		
Carroll, 2015 Australia, 2006-09	**334,559** (General)			0.3% (1018)		
Coster, 2019 UK, 2013	**42,796** (General)		0.3% (129)	0.5% (229)		
Heyerdahl, 2008 Norway, 2003	**750** (Opioid overdose)			0% (0)		
Knight, 2003 US, 1996-98	**14,109** (Refusals)			0.2% (25)		
Leggatt, 2017 Canada, 2013	**804** (Falls)				1.1% (9)	
Lerner, 2003 US, 1995-1998	**36** (Hypoglycaemia)		0% (0)			
Levine, 2016 US, 2011-13	**205** (Opioid overdose)	0.5% (1)		1% (2)		1.5% (3)
Mechem, 2002 US	**63** (Seizure)		0% (0)			
Persse, 2002 US	**151** (Aged > 65 years)	1.3% (2)				
Rudolph, 2011 Denmark, 1994-2003	**3245** (Opioid overdose)		0.4% (14)			
Schmidt, 2006 US, 2001-03	**128** (General)		0.8% (1)			1.5% (2)
Snooks, 2006 UK, 2003	**194** (Falls)				2.3% (4)	
Snooks, 2014 UK, 2003	**309** (Falls)					10% (30)
Stam, 2018 Australia, 2012-13	**2455** (Opioid overdose)	< 0.1% (1)		0.1% (2)		0.4% (11)
Tohira 2016c Australia, 2013	**11,096** (General)	0.2% (19)	0.3% (32)	0.5% (56)		
Vilke, 2003 US, 1996-2000	**998** (Opioid overdose)	0% (0)				
Wampler, 2011 US	**552** (Opioid overdose)		0% (0)			0.2% (9)

Note. UK = United Kingdom, US = United States.

2.4.4 Expected death

A limitation of using mortality as an outcome is found in the group of patients at the end of their lives due to terminal illness. Situations where death was expected, such as patients known to be at the end of their life, were included in the number of deaths in the study by Tohira et al. (2016c). However, death occurring after discharge-at-scene of a terminally ill patient does not necessarily indicate an inappropriate decision by the paramedic. In this regard, the 0.5% mortality reported by Tohira et al. (2016c) may have been lower if terminally ill patients had been excluded. Conversely, terminally ill patients were excluded from the study by Coster et al. (2019) and the 0.5% mortality reported at seven days may have been higher if they had been included. No inclusion or exclusion criteria relevant to the terminally ill were reported by Carroll et al. (2015). No comment was made about the number of terminally ill patients who died after discharge from ED in the study by Tohira et al. (2016c), thus further limiting the comparison between the arms in that study.

2.4.5 Loss to follow-up limitations

Imperfect data-linkage is an expected limitation of retrospective observational studies. The study by Tohira et al. (2016c) which compared outcomes of discharge-at-scene by paramedics with discharge from ED by doctors was limited by imperfect linkage of prehospital data with mortality data. This resulted in the uneven exclusion of 43.8% of patients in the discharge-at-scene arm compared to 1.5% in the discharge-from-ED arm. The large Australian data-linkage study by Carroll et al. (2015) did not report any loss to follow-up in the "not-transported" cohort when linking to mortality data, but loss of 38.9% when linking "non-transported" patients to hospital data. Although this study linked patient records to multiple sources of fact-of-death data, the lack of reporting of rates of loss to follow-up makes it difficult to interpret the validity of the low 0.3% rate of 7-day mortality. The study by Coster et al. (2019) reported 15% loss to follow-up due to inability to link data. This compares favourably with the study by Tohira et al. (2016c).

2.4.6 Comparing paramedic decisions against doctors' decisions

Paramedic estimations of patient acuity have been compared with doctors' estimations in previous studies (Gratton et al., 2003; Hauswald, 2002). However, as patients in those studies were transported to ED, the authors cannot be considered to have assessed the outcomes and safety of paramedic discharge-at-scene decisions. Discharge-at-scene

by paramedic is somewhat more comparable to discharge from ED by doctor; as in the study by Tohira et al. (2016c). In both cases the patients' medical need is acute and unplanned and the patients' condition is not considered serious enough to warrant admission to hospital for care. However, it is not established that inferences obtained from studying the patient population presenting to an ED are generalisable to the patient population accessing EMS for low-acuity problems in the community. Further, discharge-at-scene by paramedic differs from discharge from ED by doctor in several critical ways:

- The scope of practice and experience of clinical staff making the decision
- Diagnostic tools available to support investigation of the problem
- Number of team members contributing to patient management
- Time available to come to a decision.

2.4.6.1 Distinct scope and experience level

In New Zealand EDs discharge decisions are made by doctors who have a minimum of six years full-time education at medical school. By comparison, discharge-at-scene decisions can be made by a basic grade paramedic in New Zealand; an Emergency Medical Technician with a practice level equivalent to one year of part-time study (National Ambulance Sector Clinical Working Group, 2013).

2.4.6.2 Diagnostic tools

In ED, diagnostic tools routinely include blood tests and medical imaging such as ultrasound, x-ray and computerised tomography: none of which are available to New Zealand paramedics.

2.4.6.3 Team size

In ED, a team of clinicians and health staff is coordinated in the assessment of a patient while in EMS practice, two paramedics are the standard crew size. Further, St John New Zealand is the only EMS in a high-income country sending single-crewed transport capable ambulance responses to emergency incidents (Dicker et al., 2017; St John New Zealand, 2016a). The dispatch of single-paramedic EMS response units with no transport capability to high and low-acuity work is also a feature of EMS provision.

2.4.6.4 Decision time constraints

New Zealand EDs have a six-hour target to either admit, transfer or discharge patients (Ministry of Health, 2020a), compared to a 20 to 30-minute expected scene time for New Zealand paramedics.

Due to these obvious and significant differences, there is need for caution when comparing the safety of paramedic decisions to discharge-at-scene with doctors' decisions to discharge from ED, as was the focus of the study by Tohira et al. (2016c). The cohort of patients discharged from ED in that study was not representative of all patients discharged from ED, rather it was a subset of patients who had been transported to ED by paramedics. It is unclear if that selection method biased the outcomes towards higher or lower rates of mortality after discharge from ED. No comparison group was reported by Coster et al. (2019) or Carroll et al. (2015).

2.5 Clinical decision support tools, Early Warning Scores and checklists

None of the reviewed articles reported paramedic use of a clinical decision support tool. Neither were EWS or checklists used to augment the safety of discharge-at-scene in the general population. There are few clinical decision support tools available to paramedics to support safe discharge-at-scene decisions. A 2016 systematic review found four checklists for paramedic use, but none were suitable for the general population and none were aimed at supporting discharge-at-scene (Chen et al., 2016). This situation is somewhat analogous to discharge from ED, as noted previously. Although discharge from ED is known to be a high risk situation (Johns Hopkins University; Armstrong Institute for Patient Safety and Quality, 2014), particularly for the elderly (Hastings et al., 2008), there are no tools suitable for supporting discharge of the general population from ED (Southerland et al., 2019). Existing ED discharge support tools are primarily aimed at specific populations such as the elderly (Nielsen et al., 2020), patients with asthma (Kwok et al., 2009), or children (Irwin et al., 2016).

2.5.1 ED discharge tools and surgical checklists

To facilitate comparison with and later discussion of the eNTC, two ED discharge support tools and a surgical safety checklist are now introduced. However, they are not used by paramedics to support discharge-at-scene and thus they are acknowledged as imperfect reference points. Each section has a focus on development and validation

noting that there is little consensus or guidance available for checklist development or content (Chen et al., 2016; Hales et al., 2008; World Health Organization, 2009).

The first introduced is the Emergency Department Assessment of Chest pain Score (EDACS) (Than et al., 2014). The second is the Uncertainty Communication Checklist for Patient Discharge From the Emergency Department (hereafter referred to as the Uncertainty Communication Checklist) (Rising et al., 2020). Lastly, the Surgical Safety Checklist (Haynes et al., 2009) is reviewed.

2.5.1.1 EDACS

Patients experiencing chest pain are a common reason for calls for EMS and presentation to EDs and by default are considered high risk for major adverse cardiac events such as death or myocardial infarction. However, many patients with complaints of chest pain are at low short-term risk for a major adverse cardiac event because the pain is not related to a cardiac problem. The Emergency Department Assessment of Chest pain Score (EDACS) is designed to support safe discharge of low-risk patients with chest pain from ED (Than et al., 2014) (see Appendix C). The EDACS score is derived from variables which are known to predict short-term risk of major adverse cardiac events. These include patient demographic variables such as age and sex, and subjective clinical information such as patient reported description of the pain. These variables are then combined with objective clinical data such as electrocardiograph recordings and blood tests to guide discharge decisions. The derivation procedure for the score values was unique to EDACS and is described in the original paper (Than et al., 2014). When combined with objective clinical data it is known as EDACS Accelerated Diagnostic Pathway (EDACS-ADP) (Flaws et al., 2016) and used as a risk-stratification tool. Although EDACS-ADP has been validated for use in ED (Flaws et al., 2016) it has recently been introduced in a New Zealand pre-hospital context (Extended Care Paramedic Clinical Working Group, 2020) without validation for that setting.

2.5.1.2 Uncertainty Communication Checklist

Approximately one-third of patients are discharged from ED with a symptom-based diagnosis rather than a firm medical diagnosis: a situation of diagnostic uncertainty. The Uncertainty Communication Checklist (see Appendix D) has been developed for use in simulation based training to enhance clinician communication skills (Rising et al., 2020). The Uncertainty Communication Checklist contains 21 items and covers some of

the same ground as the eNTC in excluding life-threatening conditions. The Uncertainty Communication Checklist differs from the eNTC by a) not insisting on normal physiological observations and b) in greatly expanded requirements for communication and advice. Development of the Uncertainty Communication Checklist has been guided by a 12-step process: the Checklist Development Checklist (Stufflebeam, 2000) (see Appendix E). The Uncertainty Communication Checklist has not been validated.

2.5.1.3 Surgical Safety Checklist

Following the World Health Organization (WHO) publication of guidelines to promote safe surgery (World Health Organization, 2009) the Surgical Safety Checklist was introduced into eight hospitals globally, including one in Auckland, New Zealand (Haynes et al., 2009). The Surgical Safety Checklist contains 19 elements covering various facets of surgery including anaesthesia and ensuring right-patient right-site confirmations (see Appendix F). After its introduction, the 30-day rate of death from surgery fell from 1.5% to 0.8% and strongly validated its effectiveness (Haynes et al., 2009). Development of the Surgical Safety Checklist was based on the WHO safe surgery guidelines, which conformed to a WHO guideline development process (World Health Organization, 2009) (see Appendix G).

2.5.2 Paramedic clinical decision support tools

Paramedic clinical decision support tools are usually aligned with clinical guidance: the guidance for a particular clinical situation (such as a patient who has fallen) is distilled into an algorithm which gives a treatment recommendation (Porter et al., 2018). Consequently clinical decision support tools for discharge-at-scene situations are targeted for specific conditions such as falls (Snooks et al., 2014) hypoglycaemia and seizures (Tohira et al., 2016a) rather than the general population. Existing clinical decision support tools do not appear to be sufficiently accurate to identify patients safe for discharge-at-scene (Tohira et al., 2016a). The are no tools used to support discharge-at-scene for the general population other than the eNTC used by New Zealand paramedics.

Low implementation of the eNTC by New Zealand paramedics is mirrored by low voluntary use of clinical decision support tools in other studies. A clinical decision support tool designed to support discharge-at-scene decisions for elderly fallers in the United Kingdom was found to be used in only 12.4% of eligible patients (Porter et al., 2018). Further, paramedic use of clinical guidelines to support discharge-at-scene was

found to be less appropriate when the guidance was more general and not targeted for specific clinical situations (Gray & Wardrope, 2007).

A scoping review of paramedic decision-making when managing low-acuity patients found inconsistent use of protocols (Sheffield et al., 2016). Providing feedback to paramedics on the outcomes of their discharge decisions is essential to enable improved care (Persse et al., 2002) but paramedics are not receiving such feedback (Cash et al., 2017; Fisher et al., 2015). Lack of feedback may lead to underappreciation of the risks involved in discharge-at-scene and this may explain low voluntary use of tools designed for low-acuity populations (Porter et al., 2008), such as the eNTC. In general, research on paramedic decision-making is lacking (Perona et al., 2019).

2.5.3 Early Warning Scores

Tools based on physiological parameters such as Early Warning Scores (EWS) measure the deviation of patient observations such as pulse, blood pressure and temperature from expected values to generate a score. Existing prehospital EWS are primarily aimed toward identifying high risk patients to enable prompt escalation of care rather than identifying low-risk patients suitable for safe discharge-at-scene (Corfield et al., 2018; Shaw et al., 2017).

Reverse triage is a method of identifying patients suitable for discharge and has been compared to EWS (Caramello et al., 2019). However reverse triage is designed for hospital in-patients in the context of creating surge capacity during mass casualty events (Pollaris et al., 2018) and has not been translated to prehospital practice.

Higher EWS scores seem to predict intensive care unit admission or mortality and lower EWS scores seem to show some potential to assist paramedics to decide which patients can safely remain in the community (Challen & Walter, 2010). However, EWS are not proven to improve patient outcomes (Fisher et al., 2015) and compliance with their implementation is varied (Wuytack et al., 2017). Prehospital EWS predicted 1-day mortality but did not predict 30-day mortality (Hoikka et al., 2018) and it is thus uncertain if a low EWS score can be useful in supporting safe discharge-at-scene decisions.

2.6 Literature review summary

There is little consensus on which outcomes associated with discharge-at-scene by paramedics are most important nor when to measure them. Three studies reported 7-day

mortality after discharge-at-scene in the general population but either reached differing conclusions on the safety of this practice or offered no interpretation of their data. The range in reported mortality rates (0.3% to 0.5%) is wide when extrapolated to a large patient population. Reported mortality outcomes must be interpreted with caution and are not necessarily generalisable. This is due to lack of reporting of methodology, or methodological limitations such as loss to follow-up, inclusion of the terminally ill, or comparison to non-equivalent situations such as discharge from ED by doctors.

This lack of generalisable data is exacerbated by the absence of any validated clinical tool to reduce adverse outcomes from discharge-at-scene. No study reported the use of a checklist or clinical tool to support discharge-at-scene in the general population. The use of EWS is reported, but in the context of identifying high-acuity patients at increased risk of deterioration, not for screening a low-acuity population suitable for discharge-at-scene. Clinical decision support in the form of clinical guidelines are provided for paramedics. However, these guidelines cover only a sub-set of clinical problems and their value in supporting safe discharge-at-scene in the populations they are designed for is not established. Even though some clinical decision support tools and checklists are available, they are not validated in the pre-hospital setting. Checklists are widely used in medicine to promote safety, but there is no consensus on best-practice for checklist development or content. Paramedics infrequently use available clinical decision tools and checklists to support discharge-at-scene. The reasons for low paramedic use of such tools are unknown. The next chapter will describe the methodology of a study designed to address some of these gaps in the current knowledge.

Chapter 3 Methods

3.1 Introduction

This chapter will state the research questions and detail the study methodology. This section is structured to address key components of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations (Vandenbroucke et al., 2007). As previously discussed, St John New Zealand paramedics have increasingly discharged low-acuity patients at scene, but the outcomes are unknown. St John New Zealand paramedics have used an electronic checklist (the eNTC) to mitigate risk from discharge of patients at scene, but the effectiveness of the tool is not known.

The aim of this study is to establish the mortality of patients discharged-at-scene by paramedics in New Zealand and investigate any association between using the eNTC (the exposure) and mortality (the outcome). However, the mortality of patients discharged-at-scene, frequency of eNTC use and factors influencing eNTC use are unknown. Therefore, the research questions are:

a) What was the 1-, 3- and 7-day mortality rate of patients discharged-at-scene by paramedics in New Zealand?
b) How often was eNTC used to support discharge-at-scene?
c) Was there any association between eNTC use and 7-day mortality in patients discharged-at-scene?
d) What factors (other than eNTC use) are associated with 7-day mortality after discharge-at-scene?
e) What factors are associated with eNTC use?

A quantitative, retrospective, observational cohort study design was used to answer the research questions. This design was chosen because it is relatively economical and existing data can be used (Mann, 2003). It is an appropriate method to detect a statistically significant association between an exposure (eNTC use) and a health outcome (7-day mortality) (Vandenbroucke et al., 2007). A cohort study design is suitable because the source population (patients discharged-at-scene) and cohort of interest (cases when eNTC was used) are selected prior to identification of the outcome (mortality at seven days) (Mann, 2003; Sessler & Imrey, 2015; Song & Chung, 2010). A cross-sectional study design is not suitable because although short, the 7-day period between exposure (eNTC use or non-use) and outcome (mortality) means that data is

not recorded at a single point in time (Mann, 2003). Study design is summarised in Figure 5.

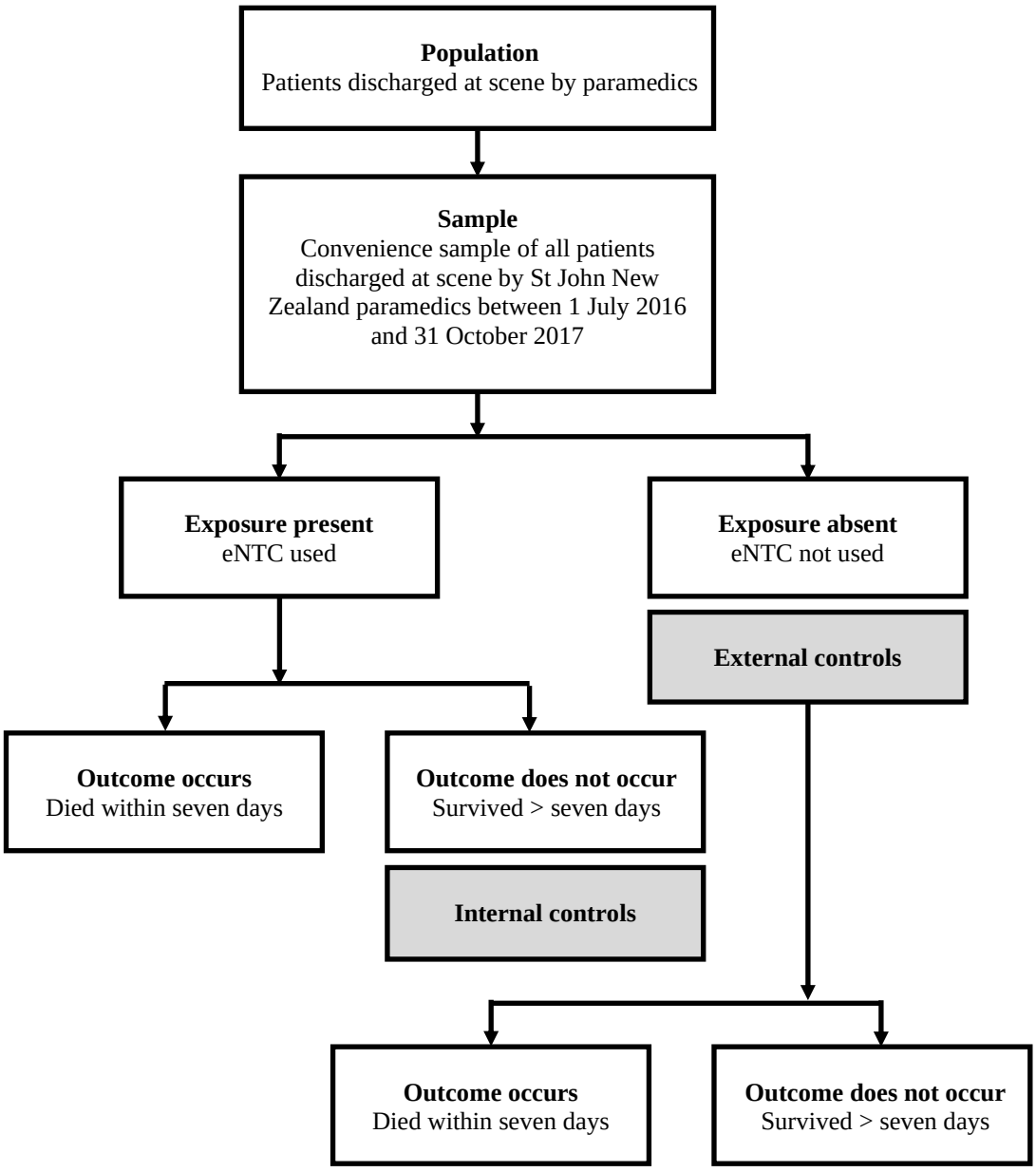

Figure 5. Cohort study design outline

A convenience sample of all patients attended by St John paramedics in New Zealand between 1 July 2016 and 31 October 2017, and who were discharged-at-scene, formed the group of eligible study participants. St John patient data was linked to Ministry of Health mortality data using the New Zealand National Health Index (NHI) number to confirm patient identity. The outcome (mortality) was compared between the two

groups; cases where the eNTC was used (exposed group) and those where the eNTC was not used (non-exposed group).

3.2 Study design

3.2.1 Study period

The study period was 1 July 2016 to 31 October 2017. These dates delimit selection of the convenience sample. During this time St John paramedics in New Zealand documented care on an ePRF and used the eNTC in an unknown number of cases when patients were discharged-at-scene. The start and finish dates of the study period were fixed by operational factors relevant to ePRF and eNTC implementation. St John New Zealand paramedics had moved from paper based to electronic reporting prior to the study period. Staged implementation of ePRF began on 14 October 2015 and was complete by 29 February 2016 (St John New Zealand, 2015). During and immediately after the ePRF roll-out period there was a low rate of NHI data collection. Using data collected before 1 July 2016 was therefore expected to result in an unacceptably high rate of cases lost to outcome follow-up due to missing NHI data. From December 2017, eNTC use was made compulsory in cases of discharge-at-scene by ePRF software updates. This means that after that date there would be no group where eNTC was not used with which to compare eNTC effectiveness. Because the primary outcome is 7-day mortality, mortality data will be linked over the date range 1 July 2016 to 7 November 2017, seven days longer than the study period. The study timeline is summarised in Figure 6.

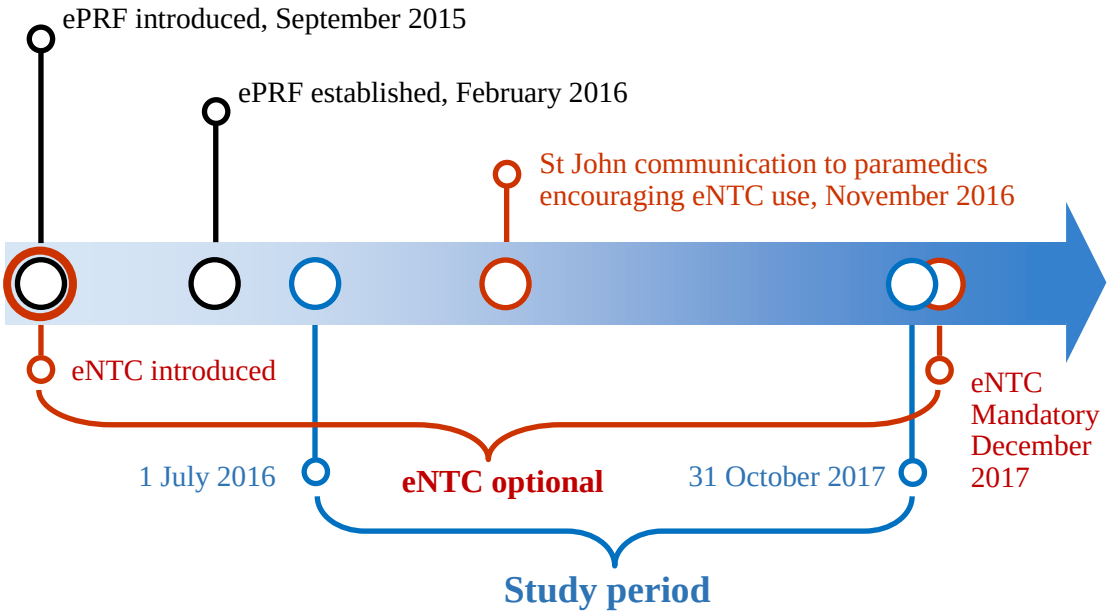

Figure 6. Study timeline

3.2.2 Setting

The setting is the area of New Zealand where EMS is provided by St John. This includes all of Te Wai Pounamu/The South Island and all of Te Ika a Maui/The North Island except that area covered by Wellington Free Ambulance. Wellington Free Ambulance provide EMS to Wellington, Kapiti and Wairarapa districts in the South of Te Ika a Maui/The North Island. Patients discharged at scene by Wellington Free Ambulance paramedics were not included in the study because they were not using ePRF and eNTC during the study period. This means the study setting covers approximately 95% of New Zealand's geographical area, and 90% of its population.

3.2.3 Participants

All patients discharged-at-scene by St John paramedics in the study period (1 July 2016 to 30 October 2017) form the study group. Patients managed with telephone triage and who have not had a face-to-face interaction with a paramedic are not included in this study. There were no exclusions for age, sex, or ethnicity. Patient demographic variables such as age, sex and ethnicity are investigated to identify any association with 7-day mortality. For the purposes of this study elderly age is defined as ≥ 65 years. This is consistent with the New Zealand Ministry of Health definition of elderly (Associate Minister of Health, 2016).

3.2.4 Case inclusion criteria

Cases were selected using St John electronic case closing codes to identify which cases resulted in the patient being discharged-at-scene. This ensured only cases involving face-to-face contact between the patient and a paramedic were included. Cases where there was no patient contact, such as standbys at the request of other emergency services or situations where no patient was found were not included.

3.2.5 Multiple attendances

In situations where a single patient had multiple ambulance attendances (cases) within seven days of death, the cases will not be collapsed into a single index event. This approach permits investigation of paramedic decision-making and eNTC use for each but may result in the inclusion of multiple cases for a single patient with each case resulting in mortality within seven days. The number of cases where this occurs is reported.

3.2.6 Case exclusion criteria

3.2.6.1 NHI linking

Cases with incomplete NHI data were excluded. Lack of NHI data prevents linking patient's data to mortality data. The proportion of missing data due to lack of NHI linking is reported.

3.2.6.2 Transport

Cases where the patient was transported were excluded. It was expected that cases where transport has occurred would not be initially selected. However, such cases were inadvertently included for selection in situations where the St John closing code used for initial case selection was incorrectly recorded. This is resolved by identifying other codes in the ePRF data record such as disposition status or transport time stamps which indicate transport has in fact occurred.

3.2.6.3 Death and expected death

Cases where patient death was expected or highly likely, such as patients coded as having an immediate threat to life (status one), palliative care and end-of-life situations were excluded. Cases where the patient died at scene were excluded.

3.2.6.4 Frequent users

Cases involving patients who meet a frequent-user definition were excluded. Although there is broad agreement that frequent users of EMS are a distinct population unrepresentative of the general population (Brown et al., 2018; London Ambulance Service, 2015) there is no consensus on how to define this group (Scott et al., 2014). Frequent use of EMS is variously defined as meeting a low threshold of ≥ 2 cases over 4 years (Scott et al., 2014) to a much higher threshold of 10 calls per month for ≥ 3 months (London Ambulance Service, 2015). For this study, a frequent user was defined as meeting any one of the following thresholds: ≥ 5 cases in any month, ≥ 9 cases in any 3-month period and ≥ 16 cases in the study period. This balanced definition aligns with St John New Zealand policy (St John Medical Director, 2019).

Exclusion criteria are summarised in Figure 7.

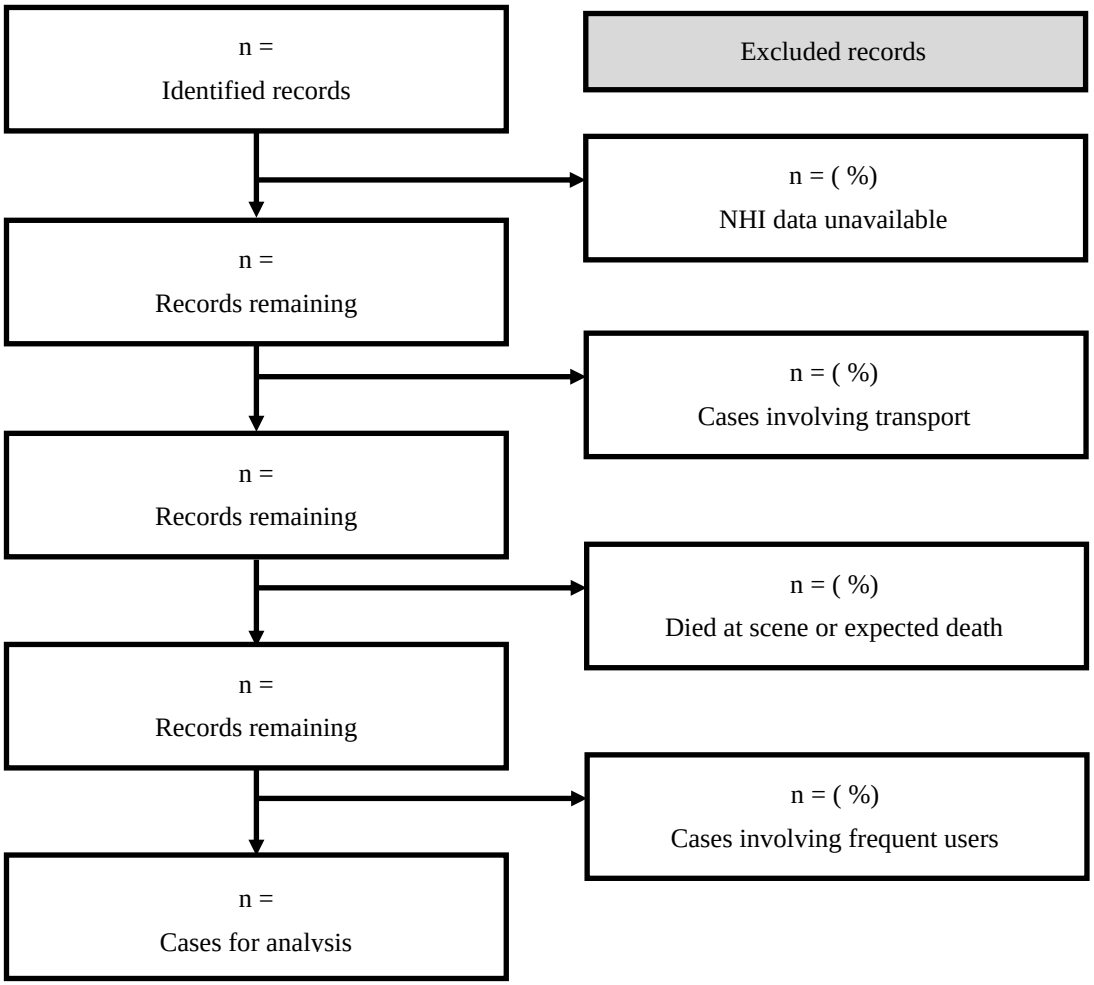

Figure 7. Exclusion criteria

3.3 Variables

3.3.1 Overview of variables

During the study period St John routinely collected data from the ePRF for purposes including research. This data includes operational variables such as destination (if transported), patient data such as demographic information and clinical data such as patient status. This was matched by a St John data analyst with operational variables such as time of day, duration of time on scene, paramedic practice level and number of EMS clinicians attending from St John Computer Aided Dispatch (CAD) data.

Ideally, in addition to recording patient name and date of birth, paramedics ensure each patient is uniquely identified on the ePRF by using NHI. Patient data collected from

ePRF was de-identified by St John data analyst and matched using NHI to mortality data. St John routinely receives mortality data from the New Zealand Ministry of Health. Key variables are summarised in Table 2. Ethics approval for the study (18/200) was granted by the Auckland University of Technology Ethics Committee on 31 May 2018 and is included as Appendix A. Locality authorisation was granted by St John on 10 August 2018 and is included as Appendix B.

3.3.2 Outcomes

With acknowledgment of these disadvantages and the lack of consensus identified with using mortality as an outcome measure noted previously, mortality at seven days is selected as the outcome of interest of discharge-at-scene for this study. Seven days is a pragmatic choice that balances a) capturing a larger number of events with b) the weaker association with longer time between exposure and outcome. Mortality at one and three days will also be measured as an outcome of secondary interest to enable comparison with other studies.

Mortality is defined as a date of death recorded by the New Zealand Ministry of Health equal to or less than seven days after the index event. The index event date is the date the patient was discharged-at-scene by paramedic and is the case date derived from St John ePRF and CAD data. The unique patient identifier the NHI number is used to link St John ePRF and CAD data with Ministry of Health mortality data. As discussed previously, for patients with more than one EMS attendance within seven days of death, those cases were not collapsed into a single index event.

Table 2. Summary of data variables

Variable	Unit of measurement	Type	Number of categories	Note	Data source
Patient					
Patient ID	NHI	String	n/a	Unique identifier	ePRF
Age	Years	Categorical	7	Calculated from DoB	ePRF
Sex	Female or male	Categorical	2		ePRF
Ethnicity	Māori, Pacific Peoples, Asian, Other, European	Categorical	5	Health Information Standards Organisation	ePRF
Clinical status	Status code 2,3,4	Categorical	3	Estimation of patient severity	ePRF
Outcome					
Date of death	≤ 7d yes/no	Categorical	2	Primary research aim	MoH
	≤ 3d yes/no	Categorical	2	To enable comparison	MoH
	≤ 1d yes/no	Categorical	2	To enable comparison	MoH
Exposure					
eNTC used	Yes/no	Categorical	2	Primary research aim	ePRF
Paramedic					
Practice level	EMT/Para/ICP	Categorical	3	Exclude first responders	ePRF
Crew number	1/more than 1	Categorical	2		ePRF
Operational					
Scene time	Minutes in 10 minute blocks	Categorical	7		CAD
Time of day	In hours or out-of-hours	Categorical	2		CAD
Response code	Grey/green, orange, red/purple	Categorical	3	Priority of response	CAD
Case date by month	Month	Categorical	16	In sequence from start to end of study period	CAD
Case date by season	Autumn, winter, spring, summer	Categorical	4		CAD

Note. CAD = computer aided dispatch, DoB = date of birth, ePRF = electronic patient report form, eNTC = electronic non-transport checklist, ID = identification, MoH = Ministry of Health n/a = not applicable, NHI = National Health Index.

3.3.3 Exposures

Use or non-use of the eNTC is the exposure being studied. The eNTC is a checklist designed to be completed by the paramedics on scene, prior to discharge-at-scene. Paramedics must complete an ePRF for every patient contact. In addition to completing an ePRF, clinical guidelines in use during the study period required paramedics to complete the eNTC for every patient contact ending in discharge-at-scene. However, prior to the study period the eNTC was only completed in approximately 25% discharge-at-scene cases (Barker, 2016). This variable will be derived from ePRF data. Cases where the eNTC was not used form the external controls for this cohort study.

3.4 Bias

This section describes features of the study design which mitigate the risk of bias. Potential sources of bias are addressed in terms of the domains relevant to observational studies described by Wang et al. (2019). Efforts to mitigate bias are reviewed with reference to criteria described by Zingg et al. (2016).

3.4.1 Selection bias

Risk of selection bias was minimised by including all cases of discharge-at-scene in New Zealand where ePRF was used. There were no exclusions for patient age, sex or ethnicity. Ethical approval was sought to include patients without consent on the grounds that; a) follow-up for tens of thousands of patients was impractical, b) use of de-identified data reduced associated risks and c) seeking consent may have caused distress to the patients relatives. Ethical approval to proceed without consent was granted. Exclusion criteria are clearly described and rationale for each exclusion criterion are detailed. The retrospective cohort study design further limits selection bias because the original data was not collected for the purpose of studying the outcome of interest (Mann, 2003).

3.4.2 Exposure

Residual risk of selection bias exists because the exposure (the eNTC) was used in only a subset of candidate cases despite being mandated by EMS policy. It is unclear why paramedics elected to use the eNTC in some cases and not others. It is possible that patient variables such as acuity influenced paramedic decision to use the eNTC and exposure is thus non-random. Although the exposed and non-exposed groups may differ (for example in age) a statistical approach to control for any confounding by variables

such as age is employed. The approach to control for confounding is described later in this chapter.

3.4.3 Outcome assessment

Outcome bias was minimised because the study population (all patients discharged-at-scene) was defined before any subjects were exposed. Further, risk of bias in identifying outcome is mitigated by using the objective outcome of mortality.

3.4.4 Confounding

Confounding is controlled by investigating collinearity prior to using standard statistical methods including multivariable logistic regression. Detail of the statistical approach to confounding is covered later in this chapter.

3.4.5 Loss to follow-up

The data linkage in this study relies on assigning an NHI (a unique identifier) to each patient. Using a unique identifier such as NHI strengthens observational data-linkage studies (Bohensky et al., 2011). The rate of cases lost to follow-up in this study is thus entirely dependent on inability to link cases due to missing NHI data. Loss to follow-up due to missing NHI precludes identifying the incidence of outcome (mortality) in the group lost to follow-up.

3.4.6 Analysis

The statistical methods chosen to investigate the association with the exposure (eNTC) and outcome (mortality) are considered appropriate to answer the question. Detail on the statistical approach is provided later in this chapter.

3.4.7 Selective reporting

Reporting and recall bias are avoided because this study does not rely on any subjective retrospective reports. Data on exposure (eNTC) and outcome (mortality) are objective and derived from independent sources.

3.4.8 Conflicts of interest

Potential conflicts of interest have been declared. The author and two of three supervisors (Bridget Dicker and Verity Todd) are employees of St John. Funding in terms of scholarship and support for professional development has been disclosed.

3.4.9 Other

The quality of information obtained is identical for both exposed and non-exposed groups. Further, outcome is assessed by reference to mortality data from a source independent from the source of the exposure data, meaning that the determination of outcome was made by an observer blinded to the exposure.

3.5 Study size

A large convenience sample was obtained. No formal sample size calculation was completed. The study start point was determined to be 1 July 2016, more than six months after the introduction of ePRF. This was because the rates of recording NHI were low in the period immediately after the introduction of ePRF. An unacceptably high rate of loss to follow-up was predicted if data was captured during this period. The endpoint of data capture for the study was determined by ending data capture one month before the date the EMS provider made eNTC use compulsory (1 December 2017). The end point of 31 October 2017 allowed a clear period between study end and mandatory eNTC use and permitted collection of mortality data one week beyond enrolment. These start and end points determined a 16-month study period.

3.6 Quantitative variables

3.6.1 Patient variables

Patient variables investigated for association with the exposure (eNTC use) and outcome (mortality at seven days) are derived from St John EMS ePRF data and include age, sex, ethnicity and clinical status. Outcome data (mortality) is derived from New Zealand Ministry of Health Mortality data. Exposure data (eNTC use) is derived from ePRF.

3.6.2 Age

Patient date of birth was used to calculate patient age. Age was handled as an ordinal categorical variable in brackets of 15 years to investigate eNTC use: this aligns with how age is handled in New Zealand Ministry of Health data sets (Ministry of Health, 2020b). However, due to low numbers of outcome events, age brackets were collapsed into two groups (< 65 years and ≥ 65 years) to investigate mortality.

3.6.3 Sex

Patient sex was investigated to identify any association between sex and eNTC use or mortality. Sex was handled as a binary female/male categorical variable.

3.6.4 Ethnicity

Patient ethnicity was investigated using New Zealand Ministry of Health prioritised ethnicity categories (Health Information Standards Organisation, 2017). Prioritised ethnicity refers to a process of ordering ethnicity when more than one ethnicity may have been recorded for an individual. This enables health initiatives to be targeted at high-need groups. Although only one ethnicity can be selected in ePRF the range of ethnicity choices is large. Using prioritised ethnicity simplifies the handling of ethnicity data in a standardised way that aligns with the New Zealand Ministry of Health approach. Ethnicity is handled as a categorical nominal variable with five values to investigate eNTC use and as a binary Māori/non-Māori variable to investigate mortality.

3.6.5 Clinical status

St John EMS status codes summarise subjective paramedic estimation of the severity (acuity) of the patient's clinical presentation. These codes are described in Table 3. Patients with status code zero (deceased) are excluded from this study as described previously. Patients with status code one (immediate threat to life) are also excluded from this study as they are deemed to have a high likelihood of death as assessed by the paramedic. Status codes two and three are considered together due to the small number of cases coded as status two. Patients with status code four (no threat to life) are expected to form most of the study population. Status codes are investigated as categorical nominal variables.

Table 3. Status codes

Status	Clinical description	Inclusion in study	Final grouping
0	Dead	Excluded	
1	Immediate threat to life	Excluded	
2	Potential threat to life	Included	Status 2 or 3
3	Unlikely threat to life	Included	Status 2 or 3
4	No threat to life	Included	Status 4

3.6.6 Outcome (mortality at 7-days)

The primary outcome being investigated by this study is death within seven days of discharge-at-scene. Fact-of-death data was obtained from the New Zealand Ministry of Health mortality data set. Death was investigated as a binary categorical variable.

3.6.7 Exposure (eNTC use)

The exposure of interest is use of the eNTC; this is handled as a binary categorical variable. If the first of the six eNTC statements was checked then the checklist was deemed to have been used. As discussed previously, eNTC use was required by policy but this was not enforced by software upgrades until after the data collection period.

Paramedic variables investigated for association with exposure (eNTC use) and outcome (mortality at seven days) are derived from ePRF data and include practice level and number of crew.

3.6.8 Paramedic practice level

As described previously, New Zealand EMS employed clinicians with four practice levels during the study period, of which three enabled the paramedics to discharge-at-scene autonomously. These three paramedic practice levels are investigated as nominal categorical variables. In cases where EMS clinicians with different practice levels attended the case the highest practice level is investigated. This is due to the responsibility for discharge-at-scene decision-making resting with the paramedic at the top of the hierarchy of practice levels. The fourth level of EMS worker (first responder) was excluded because the ability to autonomously decide to discharge a patient at scene does not sit within the first responder scope of practice.

3.6.9 Paramedic crew number

In some cases, as discussed previously, only a single paramedic would have attended the case (Dicker et al., 2017). In this situation, the lone paramedic was still expected to complete the eNTC and it is unclear what impact single-crewing will have on rate of eNTC use or mortality. Therefore, the number of paramedics in the crew was investigated as a variable of interest. This was approached as a binary single-crewed/not-single-crewed categorical variable to assess any impact of single-crewing on eNTC use or mortality.

3.6.10 Operational variables

Operational variables investigated for association with exposure (eNTC use) and outcome (mortality at seven days) are derived from CAD data and included time on scene, time of day, response code (urgency of response), case date by month and case date by season.

3.6.11 Time on scene

Duration of paramedic attendance on scene was investigated to assess any impact of longer or shorter scene times on the exposure (eNTC use) or outcome. As previously discussed, longer scene times have been associated with higher-quality care in discharge-at-scene cases. Scene time is handled as a categorical variable in 15-minute blocks.

3.6.12 Time of day

Time of day was assessed as a binary categorical variable – either in hours (defined as 0800-1959) or out-of-hours (defined as 2000-0759). Time of day was investigated to assess any impact of night-time calls.

3.6.13 Response code

St John dispatched EMS units to cases using five colour-coded levels of urgency ranging from purple (most urgent) through to grey (least urgent). Response priority may not be associated with patient acuity however, and response code will be investigated as a categorical variable with five values. Response codes are summarised in Figure 8.

Figure 8. Response codes

3.6.14 Case date

Case date by month was investigated to assess the impact of St John communication reinforcing the need for eNTC completion. St John communicated to paramedics on this topic during the study period on 28 November 2016 (St John New Zealand, 2016b). Case date by season was investigated to assess any seasonality effect. Excess winter deaths are a known phenomenon in high-income nations although the exact mechanism for them and optimal method for quantifying them are not defined (Liddell et al., 2016).

3.7 Statistical analysis

Statistical analyses were performed using the latest version of Statistical Package for Social Sciences (SPSS) software (IBM SPSS Statistics for Windows, Version 25.0 Armonk, NY: IBM Corp). Alpha (type 1 error) was set at 0.05.

Checks to ensure accurate data collection and entry were completed before commencement of analysis. The data was interrogated to detect significant outliers by using the SPSS "casewise residuals" function. No significant outliers were found for any variable. Initial analysis of the data describes the demographic features of the population including age, sex, and ethnicity of the patients. A Pearson chi-square test was used to inspect demographic, clinical, and operational variables.

The index event of discharge at scene was identified and the groups where the exposure (eNTC use) did or did not occur were identified. The rate of the outcome (mortality within seven days) was established for each group.

Univariate analyses using binary logistic regression were performed to evaluate the relationship of standard demographic, operational and paramedic variables with the exposure and then the outcome. Data was presented as Unadjusted Odds Ratios (UORs) with 95% confidence intervals (95% CI). Odds Ratios (ORs) provide a reasonable approximation of risk ratios in the context of outcomes with low (< 10%) rates of occurrence (Chen et al., 2010) as is expected for 7-day mortality after discharge-at-scene.

Multivariate logistic regression analyses were then performed to further investigate the relationship between the variables initially identified as being associated with eNTC use and mortality. Multivariate logistic regression enabled control of confounding between variables. This step permitted identification of variables independently associated with mortality and eNTC. To investigate variables associated with mortality, the following

were included by forced entry: eNTC use, age, sex, and ethnicity. Those variables with an UOR *p*-value of < .2 were included in a forward stepwise conditional model. To investigate variables associated with eNTC use the following were included by forced entry: age, sex, and ethnicity. Those variables with an UOR *p*-value of < .2 were included in a forward stepwise conditional model. Data was presented as Adjusted Odds Ratios (AORs) with 95% confidence intervals (95% CI). The variable sub-group with the largest number of cases was set as the reference group. Significance was set at $p < .05$.

To further control for confounding SPSS collinearity diagnostics were performed to ensure no highly collinear variables (those with collinearity tolerance values < 0.1) were entered into the final model (Pallant, 2016).

3.8 Reporting effect size

Finding a statistically significant result (in this study set at a *p* value < .02) indicates only that there is an association between a variable and an outcome of interest. Statistical significance does not describe the strength of that association. The magnitude of an odds ratio is also known as effect size. A larger effect size indicates a stronger association between a variable and risk of disease and this is independent of the statistical significance. The interpretation method suggested by (Chen et al., 2010) is adopted in this study to describe effect sizes. This method is summarised in Table 4.

Table 4. Reporting magnitude of effect size

Direction of effect	Magnitude of odds ratio	Effect size
Negative (reduced odds)	< 0.15	large
	0.15 – 0.28	medium
	0.29 – 0.59	small
	0.60 - 1.0	no effect
Positive (increased odds)	1.0 – 1.67	no effect
	1.68 – 3.46	small
	3.47 – 6.70	medium
	> 6.70	large

3.9 Summary

This chapter has described the study design including how the participants were selected, exclusion criteria and how exposure and outcome were measured. Efforts to minimise bias are described and the statistical approach is given including the approach to confounding. A description of effect size reporting is provided. The next chapter will report the results of the study.

Chapter 4 Results

4.1 Participants

During the study period 87,099 cases of paramedic discharge-at-scene met the inclusion criteria. This is the sample size. After exclusion criteria were applied 60,640 cases remained for analysis. Most of the excluded cases (21,267 cases, 24.4%) were excluded because they were unable to be linked with NHI data. Cases were also excluded because they involved transport (2240 cases, 2.6%), the patient died at scene or was expected to die (1364 cases, 1.6%), or the case involved frequent users (1588 cases, 1.8%). Exclusion steps are summarised in Figure 9.

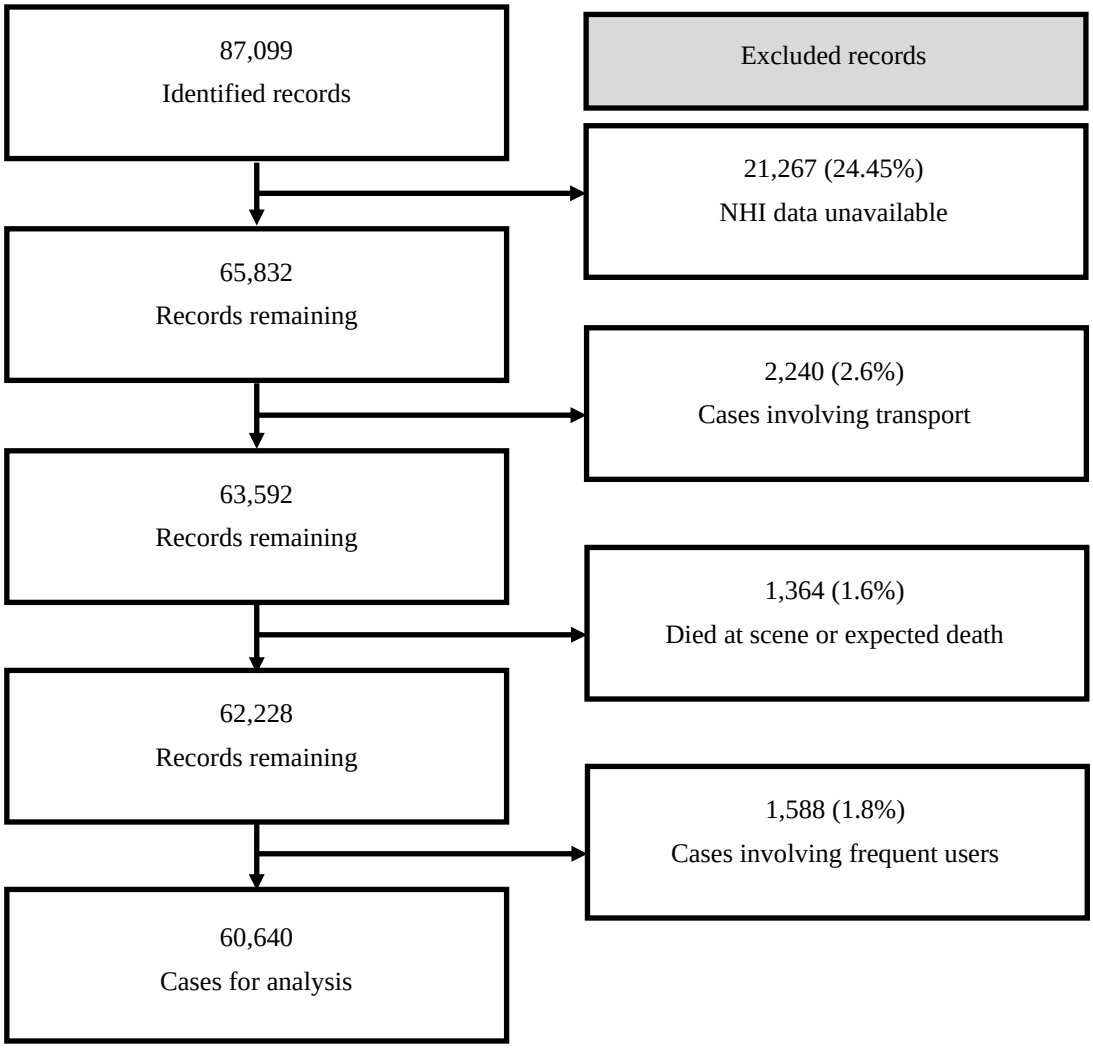

Figure 9. Summary of case exclusion steps

4.2 Descriptive data

4.2.1 Demographic descriptive data

Demographic data was available for most cases. Age data was missing for 14 cases (0.0%). Median age was 61 years [IQR: 30, 80] and ranged from new-born to 107 years (data not shown). Age demonstrated a non-normal distribution. The distribution of age data appeared left skewed and is displayed in Figure 10. Age is reported in seven age groups.

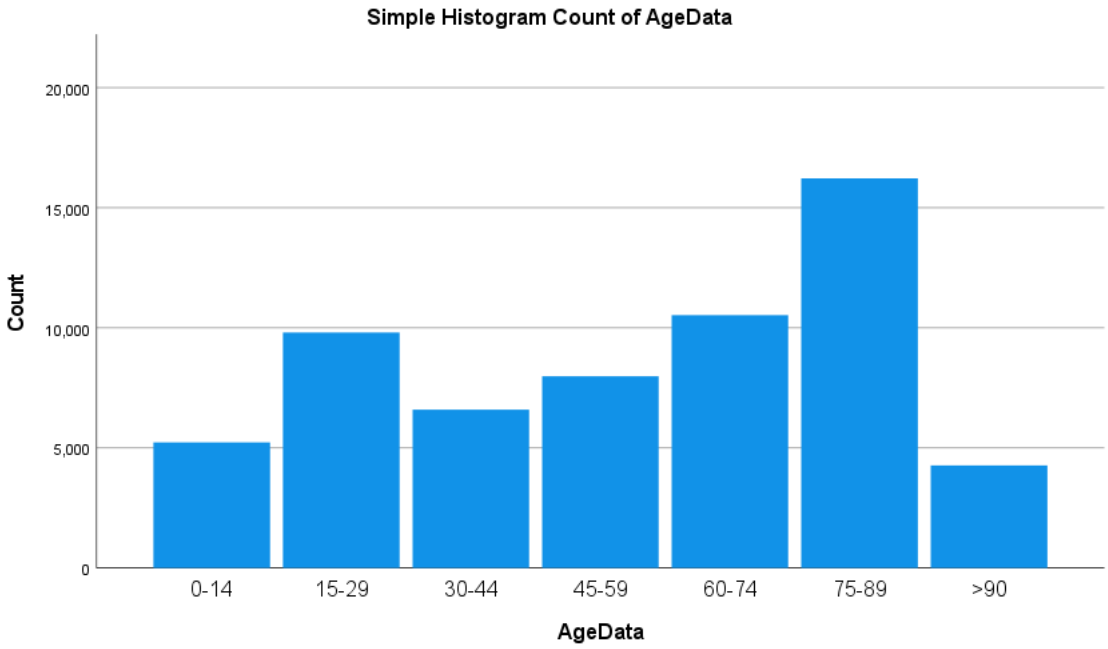

Figure 10. Distribution of age

Patient sex was missing for 37 cases (0.1%). Female patients accounted for 56.1% of the study group. Patients predominantly identified with a New Zealand European ethnicity (70.8%); ethnicity was undetermined in 776 cases (1.3%).

The relationship between demographic data and eNTC use (the exposure) and mortality within seven days (the outcome) was explored using Pearson's chi-squared test and is reported in Table 5. Statistically significant associations were identified between all demographic variables and eNTC use and between all demographic variables and mortality within seven days.

4.2.2 Temporal, operational and clinical descriptive data

Case volume increased month-by-month throughout the study period. Cases were disproportionately clustered in winter months (June, July, or August, 32.1%) and spring months (September, October, or November, 30.8%) due to how the 16-month long study period fell across seasons. Time on scene is the duration of face-face paramedic attendance. Mean time on scene was 39 minutes, standard deviation 16.53 (data not shown). Scene time data was missing in 8107 cases (13.4%). Fewer cases occurred out-of-hours (43.4%) and there was a low rate of missing time of day data (5 cases, 0.0%). The most frequently ascribed response codes were emergent (red or purple) response codes (41.5%). Every case had a response code recorded. Cases were attended by single-responder EMS crews in a minority of instances (16.4%). There were no cases missing crew number data. Most of the cases were attended by EMS clinicians with "paramedic" practice level (53.3%). Paramedic practice level data was missing in 829 cases (1.4%). Clinical status was established for all cases: the majority were assigned a "no threat to life" status code of 4 (85.7%).

The relationships between temporal, operational and clinical variables, and the dependent variables of eNTC use and mortality within seven days were explored using Pearson's chi-square test. Statistically significant associations were identified between all temporal variables and eNTC use. Of the temporal variables, seasonality and scene-time demonstrated a significant association with mortality at seven days, but case time of day did not. Temporal data and their relationship between eNTC use and mortality are reported in Table 6. Statistically significant associations were demonstrated between all operational variables and eNTC use. Of the operational variables, crew number demonstrated a statistically significant association with mortality, but response priority did not. Of the clinical variables, patient clinical status demonstrated a statistically significant association with mortality, but paramedic practice level did not. Operational and clinical data and their association with eNTC use and mortality are reported in Table 7.

Table 5. Demographic characteristics of included cases and their association with eNTC use and 7-day mortality using Pearson's chi-square test

Variable	Total cases		eNTC used		eNTC not used		*p* value	Survived > 7 days		Died ≤ 7 days		*p* value
	n	%	*n*	%	*n*	%		*n*	%	*n*	%	
Sex							**< .001**					**.001**
Female	33,994	56.1	12,839	57.5	21,115	55.3		33,865	56.1	129	46.2	
Male	26,609	43.9	9,477	42.5	17,132	44.7		26,459	43.9	150	53.8	
Missing	37											
Age							**< .001**					**< .001**
0-14	5229	8.6	1667	7.5	3562	9.3		5229	8.7	0	0.0	
15-29	9806	16.2	3386	15.2	6240	16.8		9804	16.2	2	0.7	
30-44	6594	10.9	2259	10.1	4335	11.3		6587	10.9	7	2.5	
45-59	7983	13.2	2899	13.0	5084	13.3		7961	13.2	22	7.9	
60-74	10,524	17.4	4058	18.2	6466	16.9		10,466	17.3	58	20.8	
75-89	16,220	26.8	6397	28.7	9823	25.6		16,084	26.7	136	48.7	
≥ 90	4270	7.0	1659	7.4	2611	6.8		4216	7.0	54	19.4	
Missing	14											
Ethnicity							**< .001**					**.02**
Māori	9837	16.4	3256	14.8	6581	17.4		9805	16.5	32	11.8	
Pacific Peoples	3735	6.2	1509	6.8	2226	5.9		3723	6.2	12	4.4	
Asian	2706	4.5	987	4.5	1719	4.5		2699	4.5	7	2.6	
European	42,944	71.7	16,058	72.8	26,886	71.1		42,724	71.7	220	80.9	
Other	642	1.1	238	1.1	404	1.1		641	1.1	1	0.4	
Missing	776											

Note. Significant *p*-values (< .05) are shown in boldface. eNTC = electronic non-transport checklist.

Table 6. Temporal characteristics of included cases and their association with eNTC use and 7-day mortality using Pearson's chi-square test

Variable	Total cases		eNTC used		eNTC not used		*p* value	Survived > 7 days		Died ≤ 7 days		*p* value
	n	%	*n*	%	*n*	%		*n*	%	*n*	%	
Season							**< .001**					**.01**
Winter	19,465	32.1	7263	32.5	12,202	31.8		19,363	32.1	102	36.6	
Spring	18,649	30.8	6792	30.4	11,857	30.9		18,569	30.8	80	28.7	
Autumn	11,365	18.7	4340	19.4	7025	18.3		11,300	18.7	65	23.3	
Summer	11,161	18.4	3932	17.6	7229	18.9		11,129	18.4	32	11.5	
Missing	0											
Scene time							**< .001**					**< .001**
0-19	4316	8.2	1238	6.4	3078	9.3		4305	8.2	11	4.6	
20-29	11,832	22.5	4261	22.0	7571	22.9		11,795	22.6	37	15.4	
30-39	14,326	27.3	5554	28.6	8772	26.5		14,721	27.3	55	22.8	
40-49	10,460	19.9	4075	21.0	6385	19.3		10,417	19.9	43	15.4	
50-59	5936	11.3	2285	11.8	3651	11.0		5906	11.3	30	12.4	
≥ 60	5663	10.8	1998	10.3	3665	11.1		5598	10.7	65	27.0	
Missing	8107											
Time of day							**< .001**					.23
In hours	34,331	56.6	12,324	55.2	22,007	57.4		34,183	56.6	148	53.0	
Out-of-hours	26,304	43.4	9999	44.8	16,305	42.6		26,173	43.4	131	47.0	
Missing	5											

Note. Significant *p*-values (< .05) are shown in boldface. eNTC = electronic non-transport checklist; out-of-hours (using the 24-hour clock) = 2000-0759.

Table 7. Operational and clinical characteristics of included cases and their association with eNTC use and 7-day mortality using Pearson's chi-square test

Variable	Total cases		eNTC used		eNTC not used		*p* value	Survived > 7 days		Died ≤ 7 days		*p* value
	n	%	*n*	%	*n*	%		*n*	%	*n*	%	
Priority							**< .001**					.83
Green/Grey	15,633	25.8	5648	25.3	9985	26.1		15,561	25.8	72	25.8	
Orange	19,865	32.8	7662	34.3	12,203	31.9		19,778	32.8	87	31.2	
Red/purple	25,142	41.5	9017	40.4	16,125	42.1		25,022	41.5	120	43.0	
Missing	0											
Crew number							**< .001**					**.01**
Single-crew	9954	16.4	2738	12.3	7216	18.8		9924	16.4	30	10.8	
Multiple	50,686	83.6	19,589	87.7	31,097	81.2		50,437	83.6	249	89.2	
Missing	0											
Paramedic practice level							**< .001**					.98
EMT	12,246	20.5	4786	21.7	7460	19.8		12,192	20.5	54	20.1	
Paramedic	31,853	53.3	11,545	52.3	20,308	53.8		37,710	53.3	143	53.2	
ICP	15,712	26.3	5737	26.0	9975	26.4		15,640	26.3	72	26.8	
Missing	829											
Clinical status							**< .001**					**< .001**
Status 2 or 3	8670	14.3	2494	11.2	6176	16.1		8560	14.2	110	39.4	
Status 4	51,970	85.7	19,833	88.8	32,137	83.9		51,801	85.8	169	60.6	
Missing	0											

Note. Significant *p*-values (< 0.05) are shown in boldface. eNTC = electronic non-transport checklist; EMT = Emergency medical technician, ICP = Intensive care paramedic.

4.2.3 Summary of cases: mortality at 1-, 3-, and 7-days

Within one day, 59 patients had died: a rate of 0.1%. Within three days, 116 patients had died: a rate of 0.2%. Within seven days of discharge-at-scene, 279 patients had died: a rate of 0.5%. A summary of 1-, 3- and 7-day mortality of included cases is presented in Table 8.

Table 8. Summary of cases: Mortality at 1-, 3-, and 7-days

		Survived > 1 day		**Died ≤ 1 day**	
	N	***n***	**%**	***n***	**%**
Total cases	60,640	60,581	99.9	59	0.1
		Survived > 3 days		**Died ≤ 3 days**	
		60,524	99.8	116	0.2
		Survived > 7 days		**Died ≤ 7 days**	
		60,361	99.5	279	0.5

4.2.4 Summary of cases: eNTC use

The eNTC was used in 22,327 cases: a rate of 36.8%. A summary of eNTC use within included cases is provided in Table 9. In the group of 22,327 cases where eNTC was used, 71 patients died within seven days of discharge-at-scene (AOR 0.60; 95% CI, 0.45, 0.81; $p = .001$). In the reference group of 38,403 where eNTC was not used 208 patients died within seven days of discharge-at-scene. The association between eNTC use and mortality at seven days (UOR) and the effect size of eNTC use after controlling for confounding (AOR) is presented in Table 10.

Table 9. Summary of cases: eNTC use

		eNTC			
		Used		**Not used**	
	N	***n***	**%**	***n***	**%**
Total cases	60,640	22,327	36.8	38,313	63.2

Note. eNTC = electronic non-transport checklist.

Table 10. Association between eNTC use and 7-day mortality

	Total cases		**Died ≤7 days**		**Unadjusted Odds Ratio**			**Adjusted Odds Ratio**		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		279	0.5						
eNTC used	22,327	36.8	71	25.4	0.58	0.45 - 0.77	**< .001**	0.60	0.45 - 0.81	**.001**
eNTC not used	38,403	63.2	208	74.6		reference group			reference group	
Missing	0	0.0								

Note. Significant *p*-values (< .05) are shown in boldface. eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio, AOR = adjusted odds ratio.

4.3 Outcome data

4.3.1 Analysis of 7-day mortality

Of the 60,640 cases included in this analysis the primary outcome of death within seven days was observed in 279 instances (0.5%). This establishes the 7-day mortality rate for patients discharged-at-scene by paramedics in New Zealand.

The data analysis began with an evaluation of available demographic, clinical and operational characteristics which may be associated with mortality. As the inclusion criteria sampled the whole population and the data set was large (over 60,000 cases) the data was assumed to be representative and of adequate size to support the model. A relevant set of categorical variables was available for the analysis and the data was thoroughly checked for accuracy. On this basis, use of a logistic regression method was suitable to identify the impact of individual variables on 7-day mortality after discharge-at-scene.

Review of the data to test the assumptions of logistic regression was conducted prior to analysis. The number of categories for some variables was reduced to ensure each cell contained enough events to enable computation of unadjusted odds ratios using binary logistic regression. This was necessary due to the low number of outcome events (deaths). Consequently, age was analysed using dichotomous elderly (≥ 65 years) not elderly (< 65 years) categories. Similarly, ethnicity was coded as a binary Māori/not Māori grouping. Case date by month, as an independent variable, was excluded from analysis of 7-day mortality due to the low numbers of deaths for each month. Time on scene brackets were collapsed into the following categories: 0-29 minutes, 30-59 minutes and > 60 minutes.

Univariate analyses using binary logistic regression suggested 7-day mortality was less likely to be associated with five variables. These included eNTC use (UOR, 0.58; 95% CI, 0.45, 0.77; $p < .001$), Māori ethnicity compared to any other ethnicity (UOR, 0.68; 95% CI, 0.47, 0.98; $p = .04$), summer compared to winter season (UOR, 0.55; 95% CI, 0.37, 0.81; $p = .01$), shorter time on scene compared to median scene-times (UOR, 0.71; 95% CI, 0.51, 0.99; $p < .001$), and single responder EMS crews (UOR, 0.61; 95% CI, 0.42, 0.90; $p = .01$.

Conversely, univariate analysis suggested 7-day mortality was more likely to be associated with male sex (UOR, 1.49; 95% CI, 1.18, 1.89; $p < .001$), age ≥ 65 years

(UOR, 5.94; 95% CI, 4.33, 8.15; $p < .001$), longer time on scene compared to median scene times (UOR, 2.78; 95% CI, 2.06, 3.75; $p < .001$) and more severe clinical status (UOR, 1.49; 95% CI, 1.18, 1.89; $p < .001$). Analysis demonstrated no association between 7-day mortality and time of day ($p = .23$), response priority ($p = .83$) or crew practice level ($p = .98$).

A multiple variable binary logistic regression model was used calculate AORs to identify independent variables remaining associated with 7-day mortality after controlling for confounding. Variables with an UOR p value < 0.2 were selected for entry into the model. To further control for confounding, collinearity diagnostics were performed on the suite of variables to ensure no highly collinear variables were entered into the final model. None of the independent variables demonstrated significant collinearity. Collinearity tolerance values ranged from 0.983 - 0.999, with lower values (less than 0.1) indicating the possibility of collinearity. In summary, each of the variables were independent of the others and none of the variables demonstrated a degree of collinearity which could confound the analysis.

Three independent variables remained associated with reduced 7-day mortality after controlling for confounding. Single paramedic EMS crews showed the largest effect (AOR 0.46; 95% CI, 0.30, 0.72; $p = .001$). The association between use of the eNTC and summer season with mortality were the same: eNTC use (AOR 0.60; 95% CI, 0.45, 0.81; $p = .001$), summer season (AOR 0.60; 95% CI, 0.38, 0.91; $p = .03$).

Conversely, four independent variables remained associated with increased mortality: older age ≥ 65 years showed the largest effect (AOR 6.10; 95% CI, 4.27, 8.71; $p < .001$). Other variables associated with mortality, in order of effect size from larger to smaller, include more severe clinical status (AOR 3.50; 95% CI, 2.65, 4.61; $p < .001$), longer time on scene (AOR 2.08; 95% CI, 1.52, 2.85; $p < .001$) and male patient sex (AOR 1.57; 95% CI, 1.21, 2.04; $p = .001$). Patient ethnicity was determined not to be associated with mortality.

The association between eNTC use and demographic variables with mortality is presented in Table 11. The association of temporal variables with mortality is presented in Table 12. The association of operational and clinical variables with mortality is presented in Table 13.

Table 11. eNTC use and demographic variables associated with 7-day mortality

	Total cases		**Died ≤ 7 days**		**Unadjusted Odds Ratios**			**Adjusted Odds Ratios**		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		279	0.5						
eNTC use										**.001**
eNTC used	22,327	36.8	71	25.4	0.58	0.45 - 0.77	**< .001**	0.60	0.45 - 0.81	
eNTC not used	38,403	63.2	208	74.6		reference group			reference group	
Missing	0	0.0								
Sex										**.001**
Female	33,994	56.1	129	46.2		reference group	**.001**		reference group	
Male	26,609	43.9	150	53.8	1.49	1.88 - 1.89		1.57	1.21 - 2.04	
Missing	37	0.1	0							
Age							**< .001**			**< .001**
< 65	32,618	53.8	46	16.5		reference group			reference group	
≥ 65	28,008	46.2	233	83.5	5.94	4.33 – 8.15		6.10	4.27 – 8.71	
Missing	14	0.0	0							
Ethnicity							**.04**			.38
Māori	9837	16.2	32	11.8	0.68	0.47 - 0.98		1.21	0.79 - 1.85	
Non-Māori	50,027	82.5	240	88.2		reference group			reference group	
Missing	776	1.3	7							

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio.

Table 12. Temporal variables associated with 7-day mortality

	Total cases		**Died ≤ 7 days**		**Unadjusted Odds Ratios**			**Adjusted Odds Ratios**		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		279	0.5						
Case season							**.01**			**.03**
Winter	19,465	32.1	102	36.6		reference group			reference group	
Spring	18,649	30.8	80	28.7	0.82	0.61 - 1.10		0.86	0.63 - 1.19	
Summer	11,161	18.4	32	11.5	0.55	0.37 - 0.81		0.60	0.38 - 0.91	
Autumn	11,365	18.7	65	23.3	1.09	0.80 - 1.50		1.17	0.83 - 1.66	
Missing	0	0.0	0							
Time on scene							**< .001**			**< .001**
0-29 mins	16,148	26.6	48	19.9	0.71	0.51 - 0.99		0.94	0.67 - 1.33	
30 - 59 mins	30,722	50.7	128	53.1		reference group			reference group	
≥ 60 mins	5663	9.3	65	27.0	2.78	2.06 - 3.75		2.08	1.52 - 2.85	
Missing	8107	13.4	38							
Time of day							.23			
In hours	34,331	56.6	148	53.0		reference group				
Out-of-hours	26,304	43.4	131	47.0	0.87	0.68 - 1.10				
Missing	5	0.0	0							

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio.

Table 13. Operational and clinical variables associated with 7-day mortality

	Total cases		**Died ≤7 days**		**Unadjusted Odds Ratios**			**Adjusted Odds Ratios**		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		279	0.5						
Response priority							.83			
Green and grey	15,633	25.8	72	25.8	0.97	0.72 - 1.30				
Orange	19,865	32.8	87	31.2	0.92	0.70 - 1.21				
Red and purple	25,142	41.5	120	43.0		reference group				
Missing	0	0.0	0							
Crew number							**.01**			**.001**
Single crew	9,954	16.4	30	10.8	0.61	0.42 - 0.90		0.46	0.30 - 0.72	
Not single crew	50,686	83.6	249	89.2		reference group			reference group	
Missing	0	0.0	0							
Crew practice level							.98			
EMT	12,246	20.5	54	20.1	0.98	0.72 - 1.34				
Paramedic	31,385	53.3	143	53.2		reference group				
ICP	14,712	26.3	72	26.8	1.02	0.77 - 1.36				
Missing	829	1.4	10							
Clinical status							**< .001**			**< .001**
Status 2 or 3	8670	14.3	110	39.4	3.94	3.10 - 5.01		3.50	2.65 - 4.61	
Status 4	51,970	85.7	169	60.6		reference group			reference group	
Missing	0	0.0	0							

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, EMT = emergency medical technician, UOR = unadjusted odds ratio.

4.3.2 Analysis of eNTC use

Of the 60,640 cases included in this analysis, eNTC was used to support discharge-at-scene in 22,327 cases (36.8%). Data analysis began with evaluation of the same demographic, clinical and operational variables used in the preliminary investigation of mortality, except for the variable of eNTC use.

Univariate analyses using binary logistic regression suggested eNTC use was more likely to be associated with older age, Pacific Peoples compared to European ethnicity, case date from December 2016 onwards, lower case priority, and lower EMS practice level. Conversely, eNTC use was less likely to be associated with male patient sex, younger age, Māori compared with non-Māori ethnicity, Māori compared to European ethnicity, spring and summer season compared to winter, shorter time on scene, out of hours case presentation, single paramedic crews and more severe clinical status.

Of the 13 variables identified as significantly associated with eNTC use by univariate binary logistic regression analyses, 10 were selected for entry into a multivariable forward stepwise logistic regression model. This model was used to calculate adjusted odds ratios (AORs) which identified variables associated with eNTC use after controlling for confounding. Of the three pairs of variables derived from the same data points only one of each could be entered into the final model. The basis for selection of each variable is as follows:

Case date by month was entered in preference to case date by season to investigate the impact of St John communications to paramedics encouraging eNTC use. Age was entered using seven 15-year brackets to elicit any associations relevant to younger patients. Ethnicity was entered using categories aligned with Zealand Ministry of Health prioritised ethnicity reporting, except for collapsing New Zealand European ethnicity (42,944 cases) and Other Ethnicities (238 cases) into a single category due to the small number of cases in the “Other Ethnicities” category.

Collinearity diagnostics were performed on the variables to ensure no highly collinear variables were entered into the final model. None of the independent variables demonstrated significant collinearity. Collinearity tolerance values ranged from 0.443 - 0.997, with lower values (less than 0.1) indicating the possibility of collinearity. The lowest collinearity values were obtained for the variable category groupings for age (0.540, 0.496) and ethnicity (0.475, 0.443). This indicates that although age and

ethnicity were the variables at most risk of collinearity, neither reached the threshold at which they must be treated differently within the analysis. In summary, each of the variables were independent of the others and none of the variables demonstrated a degree of collinearity which could confound the analysis.

All independent variables selected for entry into the final model were, after controlling for confounding, found to have a statistically significant association with eNTC use. Variables which were associated with eNTC use included: Pacific Peoples ethnicity compared to European ethnicity (AOR, 1.22; 95% CI, 1.13, 1.32; $p = < .001$), case date from December 2016 onwards compared to earlier case date (see Table 16), out-of-hours compared to in-hours case time (AOR, 1.09; 95% CI, 1.05, 1.13; $p = < .001$), low-acuity (green, grey or orange) response priority compared to higher response priority (see Table 17), and EMT compared to paramedic crew practice level (AOR, 1.10; 95% CI, 1.04, 1.15; $p = < .001$).

Variables which were associated with eNTC non-use use were: male compared to female patient sex (AOR, 0.93; 95% CI, 0.90, 0.97; $p = < .001$), patient age < 60 compared to patient age ≥ 75 years (see Table 14), more severe clinical status (AOR, 0.62; 95% CI, 0.58, 0.65; $p = < .001$), shorter time on scene compared to median scene times (see Table 17), and single responder EMS crews (AOR, 0.58; 95% CI, 0.55, 0.61; $p = < .001$).

One variable, out of hours case presentation, was associated with eNTC non-use in bivariate analysis but after controlling for confounding with multivariate analysis was associated with eNTC use.

The association of demographic variables (other than ethnicity) with eNTC use are presented in Table 14. The association of ethnicity with eNTC use is presented in Table 15. The association of case month with eNTC use is reported in Table 16. The association of temporal variables (other than case month) with eNTC use are reported in Table 17. The association of operational and clinical variables with eNTC use are presented in Table 18.

Table 14. Demographic variable (other than ethnicity) association with eNTC use

	Total cases		eNTC used		Unadjusted Odds Ratios			Adjusted Odds Ratios		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		22,327	36.8						
Sex							**< .001**			**< .001**
Female	33,994	56.1	12,839	57.5		reference group			reference group	
Male	26,609	43.9	9477	42.5	0.91	0.88 - 0.94		0.93	0.90 - 0.97	
Missing	37	0.1								
Age							**< .001**			**< .001**
0-14	5229	8.6	1667	7.5	0.72	0.67 - 0.77		0.73	0.67 - 0.79	
15-29	9806	16.2	3386	15.2	0.80	0.75 - 0.85		0.82	0.77 - 0.87	
30-44	6594	10.9	2259	10.1	0.81	0.77 - 0.85		0.81	0.76 - 0.87	
45-59	7983	13.2	2899	13.0	0.88	0.83 - 0.93		0.88	0.82 - 0.93	
60-74	10,524	17.4	4058	18.2	0.96	0.92 - 1.01		0.96	0.91 - 1.02	
75-89	16,220	26.8	6397	28.7		reference group			reference group	
≥ 90	4270	7.0	1659	7.4	0.98	0.91 - 1.05		0.94	0.87 - 1.02	
Missing	14	0.0								
Age							**< .001**			
< 65	32,618	53.8	11,379	51.0		reference group				
≥ 65	28,008	46.2	10,946	49.0	1.20	1.16 - 1.24				
Missing	14	0.0								

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio.

Table 15. Ethnicity association with eNTC use

	Total cases		eNTC used		Unadjusted Odds Ratios			Adjusted Odds Ratios		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		22,327	36.8						
Ethnicity							**< .001**			
Māori	9837	16.2	3256	14.8	0.82	0.79 - 0.86				
Non- Māori	50,027	82.5	18,792	82.5		reference group				
Missing	776	1.3								
Ethnicity							**< .001**			**< .001**
Māori	9837	16.2	3256	14.8	0.83	0.79 - 0.87		0.93	0.88 - 0.98	
Pacific Peoples	3735	6.2	1509	6.8	1.14	1.06 - 1.22		1.22	1.13 - 1.32	
Asian	2706	4.5	987	4.5	0.96	0.89 - 1.04		1.04	0.95 - 1.14	
European	42,944	70.8	16,058	72.8		reference group			reference group	
Other	642	1.1	238	1.1	0.97	0.84 - 1.16		1.05	0.88 - 1.26	
Missing	776	1.3								

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio.

Table 16. Case month association with eNTC use

	Total cases		eNTC used		Unadjusted Odds Ratios			Adjusted Odds Ratios		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		22,327	36.8						
Case date by month							**< .001**			**< .001**
July 2016	3120	5.1	917	4.1		reference group			reference group	
August 2016	3545	5.8	970	4.3	0.91	0.81 - 1.01		0.90	0.80 - 1.01	
September 2016	3467	5.7	1075	4.8	1.08	0.97 - 1.20		1.08	0.96 - 1.21	
October 2016	3590	5.9	1058	4.7	1.00	0.90 - 1.12		0.99	0.88 - 1.11	
November 2016	3520	5.8	1101	4.9	1.09	0.99 - 1.21		1.10	0.98 - 1.24	
December 2016	3946	6.5	1449	6.5	1.39	1.26 - 1.54		1.43	1.28 - 1.60	
January 2017	3866	6.4	1292	5.8	1.21	1.09 - 1.34		1.22	1.09 - 1.36	
February 2017	3349	5.5	1191	5.3	1.33	1.19 - 1.47		1.36	1.21 - 1.52	
March 2017	3807	6.3	1461	6.5	1.50	1.35 - 1.66		1.54	1.38 - 1.72	
April 2017	3659	6.0	1384	6.2	1.46	1.32 - 1.62		1.46	1.31 - 1.64	
May 2017	3899	6.4	1495	6.7	1.49	1.35 - 1.65		1.53	1.37 - 1.71	
June 2017	3927	6.5	1560	7.0	1.58	1.43 - 1.75		1.63	1.47 - 1.82	
July 2017	4542	7.5	1912	8.6	1.75	1.59 - 1.92		1.83	1.64 - 2.04	
August 2017	4331	7.1	1904	8.5	1.89	1.71 - 2.08		1.91	1.71 - 2.12	
September 2017	4003	6.6	1674	7.5	1.73	1.56 - 1.91		1.80	1.61 - 2.01	
October 2017	4069	6.7	1884	8.4	2.07	1.88 - 2.29		2.20	1.97 - 2.45	
Missing	0	0.0								

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio.

Table 17. Temporal variable (other than case month) association with eNTC use

	Total cases		eNTC used		Unadjusted Odds Ratios			Adjusted Odds Ratios		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		22,327	36.8						
Case date by season							**< .001**			
Winter	19,465	32.1	7263	32.5		reference group				
Spring	18,649	30.8	6792	30.4	0.96	0.92 - 1.00				
Summer	11,161	18.4	3932	17.6	0.91	0.87 - 0.96				
Autumn	11,365	18.7	4340	19.4	1.04	0.99 - 1.09				
Missing	0	0.0								
Time on scene							**< .001**			**< .001**
0-19 mins	4316	7.1	1238	6.4	0.64	0.59 - 0.68		0.60	0.56 - 0.65	
20-29 mins	11,832	19.5	4261	22.0	0.89	0.85 - 0.94		0.85	0.81 - 0.89	
30-39 mins	14,326	23.6	5554	28.6		reference group			reference group	
40-49 mins	10,460	17.2	4075	21.0	1.01	0.96 - 1.06		1.03	0.97 - 1.08	
50-59 mins	5936	9.8	2285	11.8	0.99	0.93 - 1.05		1.03	0.97 - 1.10	
≥ 60 mins	5663	9.3	1998	10.3	0.86	0.81 - 0.92		0.97	0.91 - 1.04	
Missing	8107	13.4								
Time of day							**< .001**			**< .001**
In hours	34,331	56.6	12,324	55.2		reference group			reference group	
Out-of-hours	26,304	43.4	9999	44.8	0.91	0.88 - 0.94		1.09	1.05 - 1.13	
Missing	5	0.0								

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, eNTC = electronic non-transport checklist, UOR = unadjusted odds ratio.

Table 18. Operational and clinical variable association with eNTC use

	Total cases		eNTC used		Unadjusted Odds Ratios			Adjusted Odds Ratios		
	N	**%**	***n***	**%**	**UOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
	60,640		22,327	36.8						
Response priority							**< .001**			
Green and grey	15,633	25.8	5648	25.3	1.01	0.97 - 1.05		1.06	1.00 - 1.11	
Orange	19,865	32.8	7662	34.3	1.12	1.08 - 1.17		1.08	1.04 - 1.13	
Red and purple	25,142	41.5	9017	40.4		reference group			reference group	
Missing	0	0.0								
Crew number							**< .001**			
Single crew	9,954	16.4	2,738	12.3	0.60	0.57 - 0.63		0.58	0.55 - 0.61	
Not single crew	50,686	83.6	19,589	87.7		reference group			reference group	
Missing	0	0.0								
Crew practice level							**< .001**			
EMT	12,246	20.5	4786	21.7	1.13	1.08 - 1.18		1.09	1.04 - 1.15	
Paramedic	31,385	53.3	11,545	52.3		reference group			reference group	
ICP	14,712	26.3	5737	26.0	1.01	0.97 - 1.05		1.01	0.97 - 1.06	
Missing	829	1.4								
Clinical status							**< .001**			
Status 2 or 3	8670	14.3	2494	11.2	0.65	0.62 - 0.68		0.62	0.58 - 0.65	
Status 4	51,970	85.7	19,833	88.8		reference group			reference group	
Missing	0	0.0								

Note. Significant *p*-values (< .05) are shown in boldface. AOR = adjusted odds ratio, EMT = emergency medical technician, eNTC = electronic non-transport checklist, ICP = intensive care paramedic, UOR = unadjusted odds ratio.

Chapter 5 Discussion

The previous chapter reported the results of the study beginning with a summary of the demographic, operational, and clinical characteristics of cases. The rate of 1-, 3- and 7-day mortality after discharge-at-scene and rate of eNTC use were presented next. This was followed by analysis of variables associated with 7-day mortality (other than eNTC use) and variables associated with eNTC use.

This chapter will discuss the results in terms of how well they answered the study questions and how they relate to the current literature and paramedic practice in New Zealand. Strengths and weaknesses of the study are explored with an emphasis on limitations of the results. This chapter then concludes with a summary of the findings, generalisability, originality, implications for practice and suggestions for further research.

5.1 Key results

The aim of this study is to establish the mortality of patients discharged-at-scene by paramedics in New Zealand and investigate any association between using the eNTC (the exposure) and mortality (the outcome) by a) establishing the 1-, 3- and 7-day mortality rate of patients discharge-at-scene by paramedics in New Zealand, b) establishing the frequency with which eNTC was used, c) identifying any association between eNTC use and 7-day mortality, d) identifying variables (other than eNTC use) associated with 7-day mortality and e) identifying variables associated with eNTC use.

During the 16-month study period 60,640 patients were discharged-at-scene by New Zealand paramedics and met inclusion criteria for this study. Within one day, 59 patients had died (a rate of 0.1%), within three days 116 patients had died (a rate of 0.2%). Within seven days of discharge-at-scene, 279 patients had died: this establishes the 7-day mortality rate for patients discharged-at-scene in New Zealand at 0.5%. The eNTC was used to support discharge-at-scene in 22,327 cases (a rate of 36.8%). Use of the eNTC was associated with a protective effect: patients discharged-at-scene when the paramedic used the eNTC were less likely to die at seven days (AOR 0.60; 95% CI, 0.45, 0.81; $p = .001$).

Variables (other than eNTC use) remaining associated with reduced mortality after controlling for confounding were single paramedic crews compared to non-single

paramedic crews (AOR 0.46; 95% CI, 0.30, 0.72; $p = .001$) and summer season compared to winter (AOR 0.60; 95% CI, 0.38, 0.91; $p = .03$). Variables associated with increased mortality after discharge-at-scene were patient age ≥ 65 years (AOR 6.10; 95% CI, 4.27, 8.71; $p < .001$), more severe clinical status (AOR 3.50; 95% CI, 2.65, 4.61; $p < .001$), longer time on scene (AOR 2.08; 95% CI, 1.52, 2.85; $p < .001$) and male patient sex (AOR 1.57; 95% CI, 1.21, 2.04; $p = .001$).

Variables associated with eNTC use were Pacific Peoples ethnicity compared to European ethnicity (AOR 1.22; 95% CI, 1.13, 1.32; $p < .001$), case date from December 2016 onwards compared to earlier case date (see Table 16), out-of-hours compared to in-hours case time (AOR 1.09; 95% CI, 1.05, 1.13; $p < .001$), lower response priority compared to higher response priority (see Table 17), and EMT compared to paramedic crew practice level (AOR 1.09; 95% CI, 1.04, 1.15; $p < .001$).

Variables which were associated with eNTC non-use use were: male compared to female patient sex (AOR 0.93; 95% CI, 0.90, 0.97; $p < .001$), patient age < 60 compared to patient age ≥ 75 years (see Table 14), shorter time on scene compared to median scene times (see Table 17), more severe clinical status (AOR 0.62; 95% CI, 0.58, 0.65; $p < .001$), and single paramedic crews compared to non-single paramedic crews (AOR 0.58; 95% CI, 0.55, 0.61; P < .001).

One variable, out-of-hours case presentation, was associated with eNTC non-use in bivariate analysis but after controlling for confounding with multivariate analysis was associated with eNTC use.

5.2 Mortality after discharge-at-scene

This section will now address the interpretation of mortality after discharge-at-scene with a focus on a) the 7-day mortality rate of 0.5% in comparison to the literature, b) discussion of the variables associated with mortality (with emphasis on the way eNTC use impacted mortality) and c) discussion of negative findings.

5.2.1 Mortality at 1- and 3-days

Mortality at 1- and 3-days were reported in this study to enable comparison with other studies of mortality after discharge-at-scene. However, as noted in section 3.3.2 mortality at shorter intervals after discharge-at-scene were not the main focus of this study and so were not subject to statistical analysis. Nevertheless, the 1-day mortality rate of 0.1% in this study compares favourably with the 1-day mortality rate of 0.2%

reported in the discharge-at-scene arm of the study by Tohira et al. (2016c). Further, that study reported a 1-day mortality rate of 0.1% in the discharge-from-ED arm: the cohort of patients discharged from ED by doctors. At face value, the finding of a 0.1% mortality at 1-day in this study appears to contradict the conclusion that "patients who were discharged at the scene by paramedics had a significantly higher risk of… death than those who were transported to and discharged from ED" (Tohira et al., 2016c, p. 549). Similar contrast is seen when comparing the 3-day rate of mortality in this study of 0.2% and the 3-day rate of mortality in the discharge-at-scene arm of 0.3% and discharge from ED arm rate of 0.2% (Tohira et al., 2016c). The 3-day mortality rate of 0.2% in this study also compares favourably with the 0.3% rate of 3-day mortality reported by Coster et al. (2019). Deaths at 1- and 3-days were not reported by Carroll et al. (2015).

5.2.2 Mortality at 7-days

Essentially, the 0.5% mortality rate found in this study is broadly comparable with the rate of 7-day mortality after discharge-at-scene reported by previous equivalent studies. It is identical to 7-day mortality rates reported in studies of discharge-at-scene in Australia (Tohira et al., 2016c) and England (Coster et al., 2019) and somewhat comparable to the 0.3% mortality rate reported in the Australian data-linkage study by Carroll et al. (2015). However, interpreting the New Zealand 7-day mortality rate from discharge-at-scene in an international context is impeded by differing study methodologies.

Comparison between these studies is complicated by differences in the inclusion criteria for patients with terminal illness. Patients at end of life were included by Tohira et al. (2016c), somewhat excluded (0.7% cases excluded) by Coster et al. (2019) and comprehensively excluded (1.9% cases excluded) in this study. No comment on patient exclusion was made by Carroll et al. (2015). This inconsistency also limits the generalisability of the results in this study.

Further, although two of the other studies did report 7-day mortality, that was not the primary outcome for either study. Instead, the authors of the Perth, West Australia study focused on deaths occurring within 24 hours of discharge: only these cases were subject to further analysis and 7-day mortality was included to facilitate comparison with other studies (Tohira et al., 2016c). Similarly, the authors of the UK study used 3-day mortality as the primary outcome (Coster et al., 2019) and reported 7-day mortality to

facilitate comparison (Coster et al., 2019). Deaths at 1- and 3-days were not reported by Carroll et al. (2015).

Additionally, reporting outcomes using standard referencing, that is, reporting percentages to a single decimal place, can hide subtle but important differences when reporting low frequency occurrences in a large population. Although each of these studies finds 0.5% mortality, when reported to two decimal places this study found 0.46% mortality, Tohira et al. (2016c) 0.50% and Coster et al. (2019) 0.54%.

The finding of a low rate of mortality in this study, equivalent to findings of similar international studies, suggests value in adopting mortality after discharge-at-scene as a low-acuity EMS performance benchmark. This suggestion is explored in more depth in section 5.5.1.

It is unclear how New Zealand paramedics could have discharged their duty to uphold patient rights, specifically right 6.1.b (the right to be fully informed of expected risks) (Health and Disability Commissioner, 2021) in discharge-at-scene situations given the previously unacknowledged risk of mortality. In this sense, raising awareness of the risk of mortality associated with discharge-at-scene may facilitate more honest and fact-based communication between paramedics and patients in these situations.

Death seven days after discharge-at-scene is worrying but does not necessarily constitute an adverse event. While mortality at seven days after discharge-at-scene is a concrete and objective outcome it will not always indicate a causal relationship with an inappropriate decision by a paramedic. These events are nevertheless worthy of investigation: mortality in what is expected to be a low-risk low-acuity population safe for discharge-at-scene warrants thorough case review.

In context, a 0.5% mortality rate seems low and is broadly consistent across discharge-at-scene studies, however caution is required before reaching a conclusion on how appropriate that rate is. The need for caution is not due to unflattering comparison with outcomes of discharge from ED by doctors. The argument against comparing ED discharge by doctor to discharge-at-scene by paramedic has been provided earlier in this thesis (see section 2.4.6). Rather, caution is required because of the possibility that all three studies, including this study, have found an excessive rate of 7-day mortality after discharge-at-scene when compared to the findings reported by Carroll et al. (2015). As has been noted, interpretation of that study's findings is not straightforward. This is

because, although derived from a group larger than the current and other comparable studies (Coster et al., 2019; Tohira et al., 2016c), inclusion criteria were not provided in any detail by Carroll et al. (2015) and the data was not discussed. Consequently, it seems prudent to reserve judgement regarding the acceptability of the 7-day 0.5% mortality rate after discharge-at-scene found in this study given the 0.3% rate reported by Carroll et al. (2015).

Finally, no rate of preventable mortality is "acceptable". Although this study finds an apparently low 0.5% rate of mortality (279 cases), it is unknown how many of these deaths were preventable. Understanding preventable features of each case requires further investigation. Awareness of this source of potential adverse events may be a timely warning for a paramedic profession newly registered. In summary, discretion is needed before accepting any rate of mortality after discharge-at-scene as an unquestionable reality of paramedic practice.

5.2.3 Variables remaining associated with 7-day mortality after controlling for confounding

After multivariable logistic regression to control for confounding, several variables remained associated with either increased or reduced mortality. Beginning with use of the eNTC, these variables are now discussed in the same order the data was presented in the results chapter.

5.2.3.1 Association of eNTC use with reduced 7-day mortality

After finding that eNTC use was associated with reduced 7-day mortality (AOR 0.60; 95% CI, 0.45, 0.81; p = .001), the null hypothesis that eNTC had no association with mortality after discharge-at-scene eNTC use was rejected. However, the magnitude of that association, although statistically significant, was less than small when described using the odds ratio interpretation method postulated by Chen et al. (2010) and described earlier in section 3.8. Neither previous study of mortality after discharge-at-scene reported use of a checklist (Coster et al., 2019; Tohira et al., 2016c) and therefore comparison of this result is not possible. While non-comparability of findings related to checklist use curtails discussion of the finding in context of the existing literature, it does point to the originality of this study.

The extent the contribution of each of the six components of the eNTC to the association with reduced mortality found by this study remains unknown. The components of the eNTC are repeated here for ease of reference:

1. The patient has been fully assessed including a set of vital signs and appropriate investigations.
2. No vital signs (excluding temperature) are significantly abnormal.
3. Serious illness or injury has been reasonably excluded.
4. No red flags requiring transport to ED are present.
5. The patient is seen to mobilise (when able to normally do so), noting that if the patient is unable to mobilise there must be a minor or long-standing condition preventing this.
6. The patient and/or caregivers have been given a verbal and written explanation of when to seek further clinical advice.

Some components of the eNTC (items one and two) refer to measurements of a patient's vital sign recordings and are thus aligned with features of EWS. Understanding the association between abnormal vital sign recordings and mortality may have more value than investigating other checklist components because vital sign recordings are relatively objective. Although checklist use per se was not investigated, an association between abnormal vital signs and 1-day, 3-day and 7-day mortality (OR 4.0; 95% CI, 2.8, 5.8) was reported by Tohira et al. (2016c). However, it is not apparent if this result was adjusted for confounding, nor was the statistical significance (*p*-value) reported and therefore it is difficult to determine the strength of those findings. Neither checklist use nor abnormal vital sign recordings formed part of the UK study by Coster et al. (2019). Exploring the contribution of abnormal vital sign recordings to predicting adverse outcomes from discharge-at-scene is a potential avenue to enhance eNTC effectiveness.

Conversely, item three: "serious illness or injury has been reasonably excluded" appears prudent but relatively subjective. What constitutes "reasonably excluded" is not further defined in the checklist nor the paramedic clinical guidelines (National Ambulance Sector Clinical Working Group, 2016). Additionally, the negative wording of this item, like other eNTC items, contrasts with the intent for paramedics to make a positive affirmation of eNTC statements. This may add unhelpful complexity to the eNTC. Rewording this item to become a positive statement may help strengthen the eNTC. For

example, changing the wording of item three to “only minor illness or injury has been identified” is one way of positively re-wording the statement.

Item four, (the absence of red flags), is derived from additional clinical guidance. As noted in the literature review (2.5.2), clinical guidance for specific medical problems and injuries is complex and somewhat subjective. Although specific clinical guidance is outside the scope of this study, its inclusion in the eNTC may have served as a useful reminder to paramedics to utilise whatever clinical guidance was available and relevant. Determining the value of using specific clinical guidance in conjunction with the eNTC to mitigate risk in discharge-at-scene cases is another topic worthy of further investigation.

The fifth component (ability of the patient to mobilise normally) is a novel feature of this checklist, does not feature in EWS and was not reported in other studies of discharge-at-scene. Mobility problems, for example falls, are frequently encountered in low-acuity paramedic workload. Understanding the contribution of this eNTC component to reducing adverse events will help determine its potential to feature more widely in improving the safety of discharge-at-scene.

The final components (communication and reporting requirements) appear to have less to do with the clinical situation of the patient and are more aligned with an orderly process to communicate and document high-risk clinical situations. Transition of care (such as discharge) is known to be a high-risk clinical situation. The value of strengthening communication and documentation when discharging patients with diagnostic uncertainty from ED has been noted previously (Rising et al., 2020). The current study does not however report any findings that support or refute the assertion that improved communication and documentation results in increased safety in discharge-at-scene by paramedics. The value of stressing comprehensive documentation and clear communication in mitigating risk from discharge-at-scene remains unclear.

It is likely that the contribution of individual components of the eNTC to the association between eNTC use and reduced mortality found in this study is uneven. It is even possible that some eNTC components do not contribute to enhancing patient safety. Improved discharge-at-scene safety may be achieved by revising some eNTC components or adding additional components, but this is dependent on first evaluating the contribution of individual eNTC components.

In summary, after controlling for confounding eNTC remained associated with reduced mortality after discharge-at-scene. However, the effect size was less than small, and this suggests there is utility in revising the eNTC to optimise its impact in enhancing the safety of discharge-at-scene decisions. Variables which remained associated with increased or reduced mortality (other than eNTC use) after controlling for confounding are now discussed.

5.2.3.2 Association of male patient sex with increased 7-day mortality

Male patient sex remained associated with increased mortality and demonstrated a less than small effect size (AOR, 1.57; 95% CI, 1.21, 2.04; $p = .001$). The finding of increased male mortality in this study aligns with known shorter male life expectancy compared to female life expectancy (Ministry of Health, 2015). Patient sex, specifically male sex, may be worth considering for inclusion in any revision of the eNTC and may be a variable worth including in a discharge-at-scene predictive score.

5.2.3.3 Association of older age with increased 7-day mortality

Patient age ≥ 65 years exhibited the greatest effect size of any variable associated with mortality after discharge-at-scene (AOR, 6.10; 95% CI, 4.27, 8.71; $p < .001$) and this is consistent with findings from the other studies of mortality after discharge-at-scene (Coster et al., 2019; Tohira et al., 2016c). As noted earlier, age does not currently feature in the eNTC. This finding that older age is clearly associated with mortality suggests it may be a useful criterion to include in a revised eNTC or included as a variable in a discharge-at-scene predictive score. In this study the association between age and mortality was investigated as a binary categorical variable (< 65, ≥ 65 years) due to low event numbers. Compared to other scores which utilise finer grained age brackets, for example EDACS (Than et al., 2014) this broad age grouping does not offer precision and is a limitation of this study.

5.2.3.4 Association of summer season with reduced 7-day mortality

Summer season compared to winter (AOR, 0.60; 95% CI, 0.38, 0.91: $p = .03$) exhibited a less than small-sized association with mortality. Excess winter death is a known health care challenge and the finding of reduced summertime mortality in this study fits that pattern.

5.2.3.5 Association of longer scene times with increased 7-day mortality

Scene time longer than 60 minutes remained associated with mortality and exhibited a small effect size (AOR, 2.08; 95% CI, 1.52, 2.85, $p < .001$). This finding contradicts a previously reported association between longer scene time and qualitatively better care in discharge-at-scene cases (Snooks et al., 2004). One explanation may be that paramedics were identifying patients at higher risk and consciously investing time to manage them safely in the community.

Time-consuming activities in discharge-at-scene cases include assessment, interventions, social assistance, documentation, and communication. Time-consuming assessment may have included comprehensive and detailed examination, social assessment, or repeat assessment, for example to assess the effectiveness of any medications administered or interventions performed. Ideally, repeat assessments should be well separated in time to enable identification of trends. Time-consuming interventions include activities such as dressing wounds, administering medications, and providing lifting assistance. Social assistance includes activities such as cleaning, dressing and on occasion helping with a meal, pets, or a dependant family member. The initial gathering of information, particularly for patients with a complex medical history can be time consuming. Tasks include ascertaining current medication lists, accessing and reading health records and management plans. Completing appropriate documentation such as the ePRF also takes time. Communicating findings, discussing plans, and inviting questions cannot be rushed, particularly for those with communication barriers such as vision impairment, hearing impairment, language barriers, cultural barriers, or low health literacy.

The motivations for paramedics to spend extended time on scene (> 60 minutes) is possibly best assessed in context with other factors, such as distance from hospital (Hoikka et al., 2017). Distance from hospital was not investigated as an independent variable in this study.

Discharge-at-scene in this study will have included an unknown number of cases where the patient refused transport. It is likely that the patient was competent but making a poor decision to refuse transport in some of these cases. In these situations, New Zealand paramedics have been encouraged to adopt a “harm-minimisation approach” to mitigate risk. This approach entails additional communication, planning and documentation; all of which are time-consuming.

In summary, extended scene time was found to be associated with increased mortality. This finding is at odds with the perception that paramedic care in discharge-at-scene becomes qualitatively better with longer scene time. However, caution is required interpreting this result as the scene time variable had the highest rate of missing data (13.4%) of any variable in the study. Finer-grained investigation of cases of mortality after discharge-at-scene is required to understand this relationship.

5.2.3.6 Association of single paramedic crews with reduced 7-day mortality

Intriguingly, single-crewed paramedic responses compared to non-single-crew responses were demonstrated to have a greater magnitude of association with mortality (AOR, 0.46; 95% CI, 0.30, 0.70: $p = .001$) than eNTC use or non-use. This result is unexpected, counterintuitive, and runs contrary to the prevailing narrative of risk associated with single-crewed paramedic responses. In this study 16.4% of cases were attended by a single-crewed paramedic. However, comparison of the association between single-crewed responses and mortality after discharge-at-scene with other studies is unable to be made because no other study of mortality after discharge-at-scene included the number of paramedics as a variable of interest.

Interpreting this finding of an association between single-crewing and reduced mortality after discharge-at-scene thus poses a dilemma. It is vital to emphasise that findings relevant to single-crewed paramedic units in a low-acuity population intended for safe discharge-at-scene are not generalisable to a high-acuity patient population.

Of more relevance to this study is understanding why care delivered by a single paramedic is less likely to be associated with mortality after discharge-at-scene. Paramedic experience level (independent from paramedic practice level) was not investigated as a variable in this study. Paramedic practice level (as discussed later in section 5.2.4.4) was shown not to have any association with mortality after discharge-at-scene. Paramedic recognition of the risks associated with single-crewing may result in a more cautious approach to discharge-at-scene decision-making. Conversely, some factor intrinsic to the communication and partnership between paramedics may play out in a detrimental fashion in discharge-at-scene cases.

5.2.3.7 Association of higher patient acuity with increased 7-day mortality

Paramedic description of higher patient acuity (status two or three) compared to lower acuity (status four) remained associated with mortality with a medium effect size (AOR,

3.50; 95% CI, 2.65, 4.61; $p < .001$). Although this sub-group of higher-acuity patients was smaller (8,670) than the group of lowest acuity patients (51,970) it is still a sizeable cohort which paramedics discharged-at-scene despite identifying them as not being at lowest risk. It is unclear why paramedics made this apparently contradictory decision. It could indicate a very reasonable and honest identification of increased risk. More detailed investigation of cases of mortality may help understand this finding. Low patient acuity is not a component of the eNTC, rather there is a criterion to reasonably exclude serious illness or injury. Limiting discharge-at-scene to only the lowest acuity (status four) patients may be one response to this finding, although this may in turn prompt paramedics to simply assign lower status codes to support their decisions.

5.2.4 Negative findings: variables with no associations with 7-day mortality

Several independent variables were demonstrated to have either no association with mortality (case time of day, response priority, and crew practice level) or were initially associated with mortality but this association did not persist after controlling for confounding (ethnicity). Each of these is now discussed in the order the data was presented in the results chapter.

5.2.4.1 Māori ethnicity not associated with 7-day mortality

Māori (compared to Non-Māori) ethnicity was associated with lower mortality before adjusting for confounding (UOR, 0.82; 95% CI, 0.47, 0.98; $p = .04$) but this association did not retain significance after multivariable logistic regression (AOR, 1.21; 95% CI 0.79, 1.85; $p = .38$). On initial analysis this may appear a reassuring result that shows that, unlike many other health statistics (Ministry of Health, 2019), Māori do not experience disproportionately poor outcomes from discharge-at-scene by paramedics. However, an alternative explanation for not finding an association between Māori ethnicity and mortality in this study is that Māori life-expectancy is around seven years lower than non-Māori, with the greatest mortality gaps occurring before 65 years (Phillips et al., 2017). Of note, in this study mortality risk from discharge-at-scene was most strongly associated with age > 65 years (AOR, 6.10; 95% CI, 4.27, 8.71; $p < .001$). In essence, this study may have failed to identify an actual association between Māori ethnicity and mortality after discharge-at-scene because of the shorter life expectancy of Māori. Given the strong evidence for inequitable health outcomes for Māori (Dicker, Todd, et al., 2019; Gurney et al., 2019), caution is required before accepting at face

value the negative finding in this study of a lack of association between Māori ethnicity and mortality after discharge-at-scene.

5.2.4.2 Case time of day not associated with 7-day mortality

The number and type of calls for EMS out-of-hours may be influenced by reduced availability of usual primary care services and thus may include more low-acuity and low-risk cases. Conversely, the threshold for requests for out-of-hours calls for EMS may be higher, and calls may comprise more high-acuity and high-risk cases. However, case time of day (in hours or out-of-hours) exhibited no association with mortality (p = .228). Anecdotally reported reluctance of paramedic crews to transport near the end-of-shift to avoid a late finish may manifest as a bias towards increased discharge-at-scene at end of shift (with potentially increased mortality). Any such association was unlikely to be discovered without closely correlating time of call with shift-end time but that was outside the scope of this study.

5.2.4.3 Response priority not associated with 7-day mortality

The poor correlation between response priority, as determined by CAD systems such as the Advanced Medical Priority Dispatch System, and patient acuity, has been noted previously (Gray & Walker, 2008). The finding in this study that response priority (also determined by the Advanced Medical Priority Dispatch System) was not associated with mortality (p = .83) casts further doubt on the value of that system for EMS dispatch of low-acuity cases.

5.2.4.4 Paramedic practice level not associated with 7-day mortality

Lack of association between paramedic practice level and mortality (p = .977) is counter-intuitive, somewhat reassuring for EMS providers and patients, and a further warning for the paramedic profession. Specifically, compared to the 53.3% of cases attended by paramedics, neither care delivered by lower practice level EMTs nor higher practice level ICPs demonstrated any association with increased or reduced mortality. No other studies of mortality after discharge-at-scene investigated the association between paramedic practice level and mortality so comparison is unable to be made for this variable. More highly qualified staff within a health profession may naturally assume that they will deliver better patient outcomes, but for New Zealand paramedics in discharge-at-scene situations this is clearly not the case. This finding adds to the generally cautionary messaging emerging from this study. As noted previously, New Zealand paramedics are currently being registered as health professionals, but at present

EMTs remain unregulated. Higher qualified paramedics (paramedics and ICPs) may benefit from being reminded that a higher practice level does not automatically confer superior ability to deliver better patient outcomes.

5.3 Rate of eNTC use

The eNTC was used in 36.8% of candidate cases in the study period, a higher rate than the 25% previously identified in a St John audit (Barker, 2016), although still well below the 100% rate mandated (but not enforced) by the EMS provider.

After controlling for confounding, most variables continued to demonstrate a statistically significant association with increased or decreased eNTC use. However, this was probably due to a large data set and the effect sizes for most variables were less than small. Independent variables remaining associated with eNTC with the greatest effect sizes include case date by month, single crew paramedic, and higher patient acuity. These variables are now discussed in the order the data was presented in the results section.

5.3.1 Association of later case date with eNTC use

Despite being mandated by EMS protocol the eNTC was used in only 22,327 of 60,640 cases of discharge-at-scene during the study period, a rate of 36.8%. Over the study period, eNTC use increased from month to month, from being used in 917 of 3120 cases (29%) in July 2016 at the start of the study to 1884 of 4069 cases (46%) in October 2017 at the end of the study. When compared against the month of July 2016, later case month was associated with eNTC use but this only reached significance from December 2016 onwards, see Table 16. Further, effect size was less than small until June 2017, and small from June 2017 until the study ended. Essentially, statistically significant improvement in eNTC use was only seen after the EMS provider communication to paramedics in November 2016 (St John New Zealand, 2016b) but did not approach the mandated 100% usage level at any point during the study.

Persistent non-compliance with safety protocols, such as not using the eNTC to support safe discharge-at-scene, seems inexplicable. As previously noted, paramedic compliance with protocols in discharge-at-scene situations is known to be sub-optimal: paramedics do not appear to see value in using them (Gray & Wardrope, 2007; Porter et al., 2008). This may be due to an under-appreciation of risk because of the previously under-reported rate of mortality associated with discharge-at-scene. Sharing the results

of this study may positively impact paramedic practice. Communicating the risks associated with discharge-at-scene may transform discharge-at-scene from being perceived by paramedics as a benign low-risk activity into a high-risk process requiring close attention and considered clinical judgement. The value of the eNTC in mitigating these risks may thus become clearer to paramedics, and paramedic engagement with the checklist may improve. An alternative explanation for low rates of voluntary eNTC use may be that poor procedural compliance is simply a feature of current paramedic practice, and low eNTC use is typical of that.

5.3.2 Association of short scene time with eNTC non-use

Short scene times of less than 20 minutes remained associated with non-use of the eNTC (AOR, 0.60; 95% CI, 0.56, 0.65; $p = .001$). This finding could indicate that in these cases with the shortest scene times paramedics did not find the few extra minutes required to complete eNTC. Alternatively, paramedics may have elected not to use the eNTC when they perceived the situation was straightforward or low risk. This aligns with the finding in this study that longer scene times compared to shorter scene times were associated with increased mortality. The interpretation of scene time is somewhat limited because of the high rate of missing data for this variable.

Regardless, the combination of short scene time, low voluntary eNTC use and reduced mortality suggests that paramedics can recognise low-acuity patients suitable for discharge-at-scene. Further investigation of paramedic decision-making in these cases may offer some insight about how these decisions have been made rapidly and safely. Potentially, this may identify variables suitable for addition to the eNTC. One example could be paramedic recognition of an obviously minor or trivial complaint. Currently, the eNTC does not cater for recognition of such problems, rather the wording of the relevant eNTC item is aimed at excluding serious illness or injury. In this regard, gaining an understanding of paramedic decision-making in low-acuity cases may help establish if there is any value in rewording eNTC components from negative statements (exclusion of a serious problem) to positive statements (identification of a minor problem).

5.3.3 Association of single paramedic crews with eNTC non-use

Compared to crews with more than one paramedic, single paramedic crews remained associated with non-use of eNTC after controlling for confounding (AOR, 0.58; 95% CI, 0.55, 0.61, $p < .001$). This result, given that eNTC has been shown to be associated

with reduced mortality, sits somewhat at odds with the finding that single paramedic crews are also associated with reduced mortality. Put slightly differently, if a lone paramedic is less likely to use a checklist that has been shown to have a protective association with mortality, how do we explain lower mortality associated with care delivered by single paramedic crews? The answer is probably in the differing effect sizes of these variables. While both statistically significant, the AOR of eNTC use associated with reduced mortality is 0.60 whereas the AOR of a single-crew response showed a larger effect size of 0.46. This combination of findings does not undermine the value of using the eNTC to support safe discharge-at-scene. Rather, it puts the magnitude of eNTC effect into perspective and adds impetus to revising the eNTC to maximise its protective impact on discharge-at-scene. This finding also points to the poorly understood decision-making processes of paramedics. Further research is needed to understand why paramedics operate differently when working alone.

5.3.4 Association of higher patient acuity with eNTC non-use

Subjective paramedic estimation of higher patient acuity (status two and three) showed a statistically significant association with non-use of the eNTC with a less than small effect size (AOR, 0.62; 95% CI, 0.58, 0.65; $p < .001$). This finding could indicate a situation where, despite proceeding to discharge-at-scene, paramedics had identified a high-acuity patient as being a less than ideal candidate for discharge-at-scene who was also less suited to use of the existing eNTC. The current eNTC is clearly aimed at supporting discharge-at-scene of low-acuity patients but there is no alternative "harm-mitigation" checklist to use when higher-risk higher-acuity patients are discharged-at-scene. Development of the eNTC, potentially where it moves from being a simple checklist to a score indicating clinical risk, may result in it being recognised by paramedics as a more valuable tool and make it more relevant to use in higher risk situations. As noted previously, paramedic non-compliance with protocols has been identified when paramedics perceive that the protocols are not appropriate for the circumstances. The reasons paramedics discharge higher acuity patients at scene is unknown and is worthy of further investigation.

5.3.5 Summary of low paramedic use of eNTC

Paramedic compliance with protocols mandating eNTC use improved slightly during the study period but remained low overall. Single paramedic crews, higher patient acuity and short scene time all remained associated with lower eNTC use after

controlling for confounding. Paramedic under-appreciation of the risks of discharge-at-scene and value of checklists may explain low eNTC use.

Although ePRF software upgrades have now made eNTC use compulsory for New Zealand paramedics, it is possible that the low rate of procedural compliance found in this study is replicated across other domains of paramedic practice. There may be value in conducting further research aimed at understanding paramedic discharge-at-scene decision-making, with a focus on compliance with guidelines and use of decision tools.

5.4 Limitations

This study is limited in several ways including an observational study design, exclusion criteria, methodological problems (for example missing data), and problems with using mortality as an outcome. These limitations are discussed in the following paragraphs.

5.4.1 Observational study design

Limitations inherent to the retrospective observational study design include collection of data points intended for other uses, loss to follow-up, susceptibility to selection bias and residual confounding by unknown variables. Each of these are now discussed in turn.

5.4.1.1 Data collection limitations

The data points available for collection in this study were determined by the EMS provider for requirements unrelated to this study. Rather, the data points were previously specified as being relevant to the EMS provider for the purposes of providing patient care and clinical audit. Consequently, this study was designed to investigate available data points and this limitation is typical of retrospective observational studies.

5.4.1.2 Loss to follow-up

Follow-up in this study was dependent on using the NHI to link ePRF with mortality data. However, paramedics did not record a NHI for every patient, and it is not clear why paramedics did not record NHI data for some patients. It is possible that non-collection of NHI and thus loss to follow-up was randomly distributed. Conversely, it is possible that paramedics selectively recorded less patient information (including NHI) for a non-random selection of patients for an unknown reason or reasons.

Loss to follow-up due to missing NHI and consequent inability to link to mortality data occurred in 21,267 cases out of a total of 87,099 candidate cases: a rate of 24.4%. This compares favourably with the loss to follow-up of 43.8% in the study of discharge-at-scene by Tohira et al. (2016c), but is greater than the loss to follow-up of 15% reported in the study by Coster et al. (2019). Loss to follow-up in this study is also greater than the upper limit of 20% suggested as best practice for observational studies by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) working group (Guyatt et al., 2011). As stated, it is unclear why NHI data was missing: NHI data may be missing in a random manner. In this case, risk of bias in this study may be lower if due to random loss (Kristman et al., 2004). Regardless, the frequency of outcome events (death) in the group lost to follow-up is unknown and this is a limitation of this study.

5.4.1.3 Susceptibility to selection bias

The study design addresses some potential sources of bias, for example by using an objective outcome which was recorded by independent observers blinded to the exposure. However, residual risk of selection bias exists in the potentially non-random way paramedics chose to use the eNTC. Although this has been addressed to some extent with statistical methods to control for confounding, the success of this is unknown.

5.4.1.4 Residual confounding by unknown or unexplored variables

Unknown confounders are likely to remain as potential sources of error in this study. The magnitude and impact on the outcome are undetermined. Four potentially confounding variables which were not investigated include paramedic gender, distance to hospital, timing of eNTC use and red flags/abnormal baselines. These are now each briefly discussed.

The initial research application included paramedic gender as a variable of interest. However, it was not possible to obtain this data from EMS provider records without compromising paramedic privacy. Therefore, paramedic gender was not investigated as a variable in this study. Given the potential impact of paramedic gender on discharge-at-scene decisions noted by Waldron et al. (2012), this may be a limitation of this study.

Distance to hospital reportedly weighs heavily in paramedic judgement on whether to discharge-at-scene (Hoikka et al., 2017) with the implication that increased distance to

hospital is associated with increased rates of discharge-at-scene. Distance to hospital was not investigated in this study due to the complexity involved in gathering this information.

The eNTC is intended to be completed prior to the paramedic crew leaving the scene. However, in some cases the paramedic crew had left the scene prior to completing the ePRF, and so prior to completing the eNTC. It is unclear what impact the timing of eNTC completion might have on the outcome. It is difficult to establish eNTC completion timing from ePRF case review. Therefore, timing (sequencing) of eNTC completion was not investigated as a variable.

Clinical checklists known as “red-flags” were a supplementary feature on the ePRF (in addition to the eNTC) during the study period. The red-flags lists were intended to augment discharge-at-scene decisions. One condition of successful St John locality authorisation was to identify patients where red flags had been used, especially in the context of patient refusals. However, practical limitations placed use of red-flag checklists and patient refusals beyond the scope of this study and they were not investigated. This non-adherence to the locality authorisation has been notified to St John.

Abnormalities in baseline physiological recordings such as blood pressure and heart rate are another variable of interest in studying the population of patients discharged-at-scene by paramedics. Abnormal baselines were listed in the initial research application as a variable of interest. However, practical limitations also placed abnormal baseline recordings beyond the scope of this study, and they were not investigated.

Red-flags and abnormal baselines are relevant to discharge-at-scene outcomes and their omission from this study is a limitation. Both are worthy topics for future research.

5.4.2 Exclusion criteria

Exclusion criteria impacting the generalisability of this study include the way palliative care patients and frequent callers were excluded.

5.4.2.1 Palliative care patients excluded

Cases where patient death was expected, such as palliative care and end-of-life situations were excluded from analysis (n = 1135) as previously noted. However, patients receiving palliative care may live for some years. Excluding these patients may

have resulted in this study missing cases of unexpected mortality after discharge-at-scene. Because these cases were excluded prior to analysis it is not known how many instances of mortality at seven days may have occurred in this group and what impact that may have had on the results.

5.4.2.2 Frequent users excluded

As detailed previously, cases that met a frequent-user definition of ≥ 5 cases in any month, ≥ 9 cases in any 3-month period and ≥ 16 cases in the study period were excluded. Although the argument for excluding these cases (*n* = 1588) seems logical, the net result is that mortality after discharge-at-scene in this group remains unknown. Further, this study does not report the residual proportion of frequent users in this study with a lower rate of multiple ambulance attendances that did not meet threshold for exclusion.

5.4.3 Methodological problems

Methodological problems limiting generalisability of these results include the way patients with multiple calls in the seven days prior to death were handled, and missing data.

5.4.3.1 Multiple EMS calls with seven days of death

As previously noted, situations where a patient had multiple attendances within seven days of death were included. This occurred on two occasions for each of six patients; meaning that for these six patients, 12 deaths were included in the mortality data and this is a limitation of this study. Advice from the Auckland University of Technology biostatistician on this matter was to consider collapsing these cases into a single index event. The methodology of the study completed by Tohira et al. (2016c) also followed this process of collapsing multiple cases into an index event. The logic for this is that death is a unique event. An alternative view was adopted by the supervisory team that this study was investigating paramedic decision-making in choosing to use (or not use) eNTC. The study proceeded without collapsing those 12 cases into six index events.

5.4.3.2 Missing data: scene time

Scene time was the variable with the highest rate of missing data; 13.4% of cases did not have scene time data recorded. This number includes 189 cases (0.3%) where scene time exceeded 120 minutes. Cases of extremely long scene times > 120 minutes were treated as missing data, although some may genuinely have been just very long scene

times. Interpretation of the impact of this variable on mortality and eNTC use is therefore limited.

5.4.4 Limitations of using mortality as an outcome

As noted previously in section 1.13.6, the argument in favour of selecting mortality at seven days after discharge-at-scene as the outcome of interest for this study is based on mortality being an objective and concrete measure. However, the limitations inherent in this choice include difficulty inferring a causal association between discharge-at-scene decisions by the paramedic and mortality, and the way other outcomes of importance are not investigated.

Although justified to an extent, the selection of 7-day period between discharge-at-scene and outcome is somewhat arbitrary. Seven days may be too long to establish a causal association between paramedic decisions and mortality. Mortality does not necessarily indicate an inappropriate decision by a paramedic even with a shorter time between event and outcome: this study does not include a detailed review of the 297 cases of death at seven days. Specifically, this study does not include an analysis of cause of death. Appropriateness of paramedic decision-making was considered by (Tohira et al., 2016c) who found that inappropriate decision-making in five of 19 patients who died within one day of discharge-at-scene. However, this was based on case review, did not report cause of death, and did not report case review of the larger group of 56 patients who had died within seven days of discharge-at-scene in that study.

Further, while mortality is clearly a disastrous outcome for a patient and their family, there are other outcomes which are also of value to understand and where possible, avert. Other outcomes of interest include repeat requests for EMS, attendance at ED, hospital admission, length of stay in hospital and intensive care unit admission. This study does not offer any insight into those outcomes. The two studies used as primary comparators for this study did report outcomes other than mortality after discharge-at-scene. Repeat requests for EMS, ED attendance and hospital admission after discharge-at-scene were reported by Tohira et al. (2016c) and Coster et al. (2019) but length of stay in hospital and intensive care unit admission were not reported. Conducting further research to identify and define outcomes other than mortality and developing a methodology to investigate their association with discharge-at-scene may enable benchmarking with other studies and offer opportunities to improve safety of discharge-at-scene.

5.4.5 Generalisability

The strengths of this study include its large size, broad inclusion criteria, clearly reported methodology and relatively low loss to follow-up. Because this study reports the outcomes of a large group of the general population discharged-at-scene by paramedics the results are expected to be broadly generalisable to paramedic practice in other high-income nations.

5.5 Implications for practice

This is the first study to establish the 7-day mortality of patients discharged-at-scene in New Zealand and the first study internationally to investigate use of a checklist to support discharge-at-scene. Major themes identified in this study include the potential adoption of 7-day mortality after discharge-at-scene as a low-acuity EMS benchmark, promoting checklist use and effectiveness, and raising paramedic awareness of the mortality risk associated with discharge-at-scene. These themes are now discussed in turn.

5.5.1 7-day mortality: a potential low-acuity EMS performance measure

As noted previously, key performance indicators for EMS traditionally measure response times rather than patient-centred outcomes. At present, when patient outcomes are measured, the focus is on high-acuity situations such as cardiac arrest. An example of high-acuity outcome measurement is the way New Zealand EMS performance reporting includes data for an outcome associated with cardiac arrest: return of spontaneous circulation sustained on arrival at ED (National Ambulance Sector Office, 2020). New Zealand EMS providers publish a comprehensive annual cardiac arrest outcome report (Dicker, Oliver, et al., 2019; Dicker et al., 2020).

In contrast, outcomes for low-acuity EMS workload are not currently reported in New Zealand. There is clear value in reporting cardiac arrest outcomes as part of a strategy to improve rates of cardiac arrest survival. However, bias towards reporting only high-acuity outcomes risks overlooking potentially modifiable adverse patient outcomes associated with low-acuity care. The outcome of 7-day mortality after discharge-at-scene is, as previously noted, an imperfect low-acuity measure. Regardless, a low-acuity outcome is currently missing from the EMS performance dashboard. Addressing this gap may not be straightforward. In addition to navigating risks inherent in reporting negative outcomes, unresolved methodological variability exists. Consistency in defining exclusion criteria for the terminally ill and the timeframe (1-, 3- or 7-days) at

which to measure mortality is likely to be required prior to the adoption of mortality after discharge-at-scene as a low-acuity EMS performance benchmark.

Variation noted in rates of discharge-at-scene between EMS providers, with the implication that a higher discharge-at-scene rate is desirable (O'Cathain et al., 2018), suggests benchmarking transport ratios may be of value. However, this approach risks missing the point of patient-centred care. It may be more appropriate to prioritise safe discharge-at-scene decisions for patients rather than aiming to simply increase the number of patients managed in the community. Benchmarking mortality after discharge-at-scene may be the more useful measure because it is more patient-centred.

In summary, mortality after discharge-at-scene may add a valuable patient centric low-acuity performance measure to EMS benchmarking. Further work is required to gain consensus on the ideal timeframe at which to measure mortality and agreement on the approach to exclusion criteria for the terminally ill.

5.5.2 Enhancing effectiveness of the eNTC

Finding an association between eNTC use and reduced mortality suggests eNTC use should become mandatory when paramedics discharge patients at scene. That was indeed the case in New Zealand when the eNTC became compulsory by means of software updates in December 2017. However, analysis of the association between eNTC use and reduced mortality found only a modest effect size of the checklist in its current form. This study did not shed any light on which components of the checklist were most useful. Revising the checklist to include variables found in this study to be associated with mortality (such as patient age and sex) may enhance its effectiveness. Transforming the eNTC from a checklist into a score predicting clinical risk is an alternative method to enhance effectiveness: this concept is discussed further in section 5.6.6.

This study did not measure the timing of eNTC use. It is possible that paramedics are now completing the eNTC as mandated, but in a perfunctory manner. Paramedics may be completing the eNTC after the discharge-at-scene decision has been made and possibly after the paramedics have left the address: that is, retrospective eNTC completion. Paramedics may be using the eNTC in this way, taking the minimum viable action to ensure compliance, because they do not recognise the value of the eNTC in reducing the rate of adverse outcomes from discharge-at-scene. Alternatively,

paramedics may have become familiar with the eNTC components and routinely incorporate them into their standard practice in discharge-at-scene cases. Investigating the timing of eNTC use may give some insight about how paramedics approach its use. Communicating the value of the eNTC may improve paramedic engagement with its use and may enhance its effectiveness.

It is possible that the wording of the checklist items does not promote utility. For example, item three of the eNTC states “serious illness or injury has been reasonably excluded”. Potentially, to avoid positive affirmations of negative statements, this item might be reworded as “Only minor illness or injury has been identified”. Rewording eNTC components from negative statements (such as excluding serious problems) to positive statements (identification of minor problems) may be one way to increase its effectiveness.

However, rewording statements (as described above) neglects situations where discharge-at-scene is being considered for cases that are clearly not minor. As discussed previously in section 2.5.2 it has been established that paramedic compliance with protocols is reduced when the protocols are not perceived as being relevant to the situation. It is possible that paramedics did not fully engage with the eNTC because they did not consider it a suitable tool to support discharge-at-scene of more complex patients. This may have occurred when paramedics were unable to confirm individual components of the eNTC, for instance when vital sign recordings were obviously abnormal or when serious illness was not able to be reasonably excluded.

Transient deviations from normal baseline observations are expected in the clinical course of some medical conditions which, when managed appropriately, are then suitable for discharge-at-scene. An example is the temporarily increased heart and respiratory rates associated with asthma exacerbations. In this setting, an initial set of abnormal physiological observations is expected to be followed (after suitable treatment) with a more normal set of observations. This demonstrates a reassuring trend and supports the decision to discharge-at-scene. However, the fixed nature of the eNTC does not permit more than one answer to the statement “no vital signs (excluding temperature) are significantly abnormal”. In this setting, the paramedic may have felt that regardless of how they answered this checklist item (either affirmatively or negatively), it would not accurately reflect one of the two sets of baseline observations.

It is not clear what course of action should be taken by a paramedic who completes the eNTC, notes that serious illness has not been reasonably excluded, but where discharge-at-scene is nevertheless the chosen disposition of the case. This sequence of events may occur in situations where a competent patient refuses a recommendation for transport. In this situation the ePRF has a section to capture patient refusal of care. However, as discussed in section 1.11, due to the power imbalance in the paramedic-patient relationship, specifically the concern that paramedics may unduly influence patient decisions to refuse transport, this situation was considered as equivalent to being discharged-at-scene by a paramedic. Consequently, this study did not report patient refusals. This is a limitation of this study. Investigating the current EMS approach to competent but unwise patient refusals is an area worthy of further study.

Further development of the eNTC should ideally proceed with reference to best practice medical checklist development guidelines, noting the current lack of consensus in this area. Therefore, development of the eNTC may be dependent on first identifying the preferred checklist development process.

Finally, aligning the name of the eNTC with the preferred terminology for the process (changing non-transport checklist to discharge-at-scene checklist) may be useful in highlighting the relevance and value of the checklist to paramedics.

5.5.3 Raising paramedic professional awareness of risk

Raising paramedic awareness of the risks associated with discharge-at-scene, specifically the 7-day mortality rate of 0.5% found in this study, may be a useful way to improve patient safety. As discussed previously in section 2.5.2, paramedics do not receive feedback on the outcome of their care for patients. Ideally, increased awareness of this specific consequence of discharge-at-scene may promote more considered paramedic decision-making. Paramedic recognition of the risks identified in this study may help address any currently unquantified contribution of poor paramedic decision-making to avoidable mortality associated with discharge-at-scene.

Further, the recently introduced regulation of the paramedic profession in New Zealand will result in individual paramedics experiencing a new degree of public scrutiny. Raised awareness of the potential risks associated with discharge-at-scene decisions may be a timely cautionary message for paramedics. Loss of professional registration and livelihood are potential consequences stemming from paramedic liability for poor

discharge-at-scene decisions. These are consequences New Zealand paramedics have not previously faced.

5.6 Suggestions for future research

Several potential avenues for further research have been identified in the preceding discussion. These include investigating the cause of death of the 279 patients who died within 7 days of discharge-at-scene to determine the appropriateness of paramedic decision-making, understanding outcomes other than mortality, understanding paramedic decision-making, evaluating checklist components, identifying a checklist development process, and transforming the eNTC into a risk-prediction score. Each of these suggestions is now discussed in turn.

5.6.1 Investigating cause of death

Finding patient death within seven days of being discharged-at-scene is, to a degree, unexpected and suggests an avoidable adverse outcome. However, without investigating the cause of death, this assertion remains unproven. It is possible that a perfectly reasonable decision was made by the paramedic to discharge-at-scene, and the patient subsequently died from an unrelated event. Unless cause of death is investigated, and cases of discharge-at-scene subjected to clinical review, the proportion of avoidable deaths will remain unknown. Investigation of these cases in more depth may also highlight additional modifiable factors contributing to mortality and inform eNTC revision.

5.6.2 Investigating outcomes other than mortality

While mortality is an objective outcome measure, there are other outcomes such as avoidable admission to hospital and prolonged length of stay which may be associated with discharge-at-scene. These outcomes are likely to be more frequent than mortality and identifying any association with discharge-at-scene decisions is likely to be more problematic. In combination this suggests that investigating non-fatal outcomes may be complex. The expected complexity associated with measuring non-mortality outcomes put them outside the scope of this study, and it was for this reason that these outcomes were not investigated in this study. However, avoidable admission and prolonged length of stay are standard adverse outcomes used in quality review of health systems. Difficulty measuring them should not unduly prohibit this area of paramedic practice from being subject to review. Investigating the association of non-fatal adverse

outcomes with discharge-at-scene may identify further modifiable variables suitable for incorporation into a revised eNTC and potentially enhance patient safety.

5.6.3 Investigating paramedic decision-making and checklist use

While this study has reported some outcomes of paramedic decisions to discharge patients at scene, their decision-making process remains obscure. Associated reluctance by paramedics to use mandated clinical checklists such as the eNTC is equally unexplained. Poorly understood paramedic decision-making is a previously identified knowledge gap and was discussed earlier in section 2.5.2. Investigation of paramedic decision-making in low-acuity but high-complexity and high-risk discharge-at-scene cases is called for. Such research may identify modifiable paramedic thought patterns or behaviours currently leading to adverse outcomes such as mortality after discharge-at-scene.

It is unknown exactly when during the patient contact event paramedics completed the eNTC. Although eNTC use has now become mandatory by means of software updates, it remains possible that paramedics may be completing the checklist after leaving the scene: retrospective eNTC use. Therefore, investigating the timing of eNTC use may give some insight about how it is being used and offer some opportunities to improve its effectiveness in reducing preventable mortality after discharge-at-scene.

5.6.4 Evaluating checklist components

Any revision of the eNTC is dependent on understanding the individual contribution of checklist components. Further research is required to disentangle the contribution of each checklist item, noting that objective items (such as physiological recordings) which are aligned with EWS appear a priority for research.

5.6.5 Identifying an optimal checklist development process

Increasing use of checklists in health systems in general and EMS in particular calls for evidence-based methods to guide medical checklist development. This may require development and validation of a checklist development process.

5.6.6 Translating the eNTC into a predictive score

Further evolution of the eNTC into a predictive score may make it applicable to a wider range of discharge-at-scene situations and enable validation. A predictive score development and validation process similar to that used by (Than et al., 2014) in the

development of EDACS may be useful. A validated predictive score indicating risk of mortality after discharge-at-scene may be perceived as more useful and relevant by paramedics and facilitate open discussion of risks with patients.

Chapter 6 Conclusion

This study is the first to report use of a checklist (the eNTC) in reducing mortality associated with discharge-at-scene by paramedics. Against a background of rising low-acuity EMS demand, where paramedics increasingly discharge patients at scene, this study reviewed 60,640 cases of discharge-at-scene in New Zealand. In this group, 59 patients died within one day: a rate of 0.1%, 116 patients died within three days: a rate of 0.2% and 279 patients died within seven days of being discharged-at-scene: a mortality rate of 0.5%. These rates are low, broadly equivalent to rates of mortality reported from other studies of discharge-at-scene and generalisable to paramedic practice in high-income nations. However, caution is required before accepting the 0.5% 7-day mortality rate found in this study as an unavoidable consequence of discharge-at-scene.

Mortality after discharge-at-scene shows value as a novel low-acuity EMS performance benchmark, but its adoption is first dependent on achieving consensus about exclusion criteria for the terminally ill and the ideal timeframe at which mortality should be measured.

The eNTC was used in 36.8% of cases. Use of the eNTC was associated with reduced mortality (AOR 0.60; 95% CI, 0.45, 0.81; $p = .001$). However, the effect size of eNTC use was smaller than other variables not currently included in the eNTC, such as patient age ≥ 65 years and male patient sex. This suggests that eNTC may be revised to incorporate such variables to enhance its effectiveness.

Paramedics, as newly regulated health professionals, will face increased scrutiny and accountability. Awareness of the risks identified in this study will support paramedics to more fully discharge their responsibilities to inform patients of the risks associated with discharge-at-scene. Raised paramedic awareness of these risks may contribute to lower rates of mortality. Paramedic appreciation of this previously unacknowledged risk may also help them navigate the risks of loss of registration and livelihood potentially associated with culpability in adverse outcomes associated with discharge-at-scene.

Determining the appropriateness of paramedic decision making in cases of mortality after discharge-at-scene requires case review, including review of cause of death. Health outcomes other than mortality, such as repeat calls for EMS, attendance at ED,

avoidable hospital admission and prolonged length of stay also have value in understanding the outcomes of discharge-at-scene.

Other opportunities for further research include exploring paramedic decision-making, evaluating individual checklist components, and identifying an optimal checklist development process. Gaining an understanding of how paramedics decide to discharge higher risk patients at scene, and how paramedics use clinical decision tools may help identify additional opportunities to mitigate risk.

The contribution of individual eNTC components to mitigating risk is not known. Further development of the eNTC to enhance its effectiveness in mitigating risk is dependent on understanding the value of each checklist item. Prioritising evaluation of the more objective checklist items (such as the deviation of vital sign observations from expected values) may be a sensible strategy. Identification of a best-practice medical checklist development process to guide revision of the eNTC is suggested.

Translation of the eNTC into a discharge-at-scene mortality prediction score is a potential goal for further research. Development and validation of such a score would provide paramedics with a superior clinical decision support tool to evaluate and mitigate risks associated with discharge-at-scene.

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Glossary of Terms

Abbreviation	Term
AOR	Adjusted odds ratio
CAD	Computer aided dispatch
ED	Emergency department
EMS	Emergency medical service
EMT	Emergency medical technician
eNTC	Electronic non-transport checklist
FR	First responder
ePRF	Electronic patient report form
EWS	Early warning score
GP	General practitioner
ICP	Intensive care paramedic
NHI	National health index
PICO	Population, intervention, comparator and outcome
PRISMA-P	Preferred reporting items for systematic review and meta-analysis protocol
QALY	Quality-adjusted life year
STROBE	Strengthening the reporting of observational studies in epidemiology
UOR	Unadjusted odds ratio

Appendices

Appendix A: AUTEC Approval Letter

31 May 2018

Bronwyn Tunnage

Faculty of Health and Environmental Sciences

Dear Bronwyn

Ethics Application:18/200 **Outcomes of patients discharged at the scene by paramedics in New Zealand.**

I wish to formally advise you that the Auckland University of Technology Ethics Committee (AUTEC) has **approved** your ethics application at its meeting of 28 May 2018.

This approval is for three years, expiring 28 May 2021.

Non-Standard Conditions of Approval

1. Provision of an assurance that data will be securely stored in the office of the primary supervisor.

Non-standard conditions must be completed before commencing your study. Non-standard conditions do not need to be submitted to or reviewed by AUTEC before commencing your study.

Standard Conditions of Approval

1. A progress report is due annually on the anniversary of the approval date, using form EA2, which is available online through http://www.aut.ac.nz/researchethics.
2. A final report is due at the expiration of the approval period, or, upon completion of project, using form EA3, which is available online through http://www.aut.ac.nz/researchethics.
3. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form: http://www.aut.ac.nz/researchethics.
4. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
5. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.

Please quote the application number and title on all future correspondence related to this project.

AUTEC grants ethical approval only. If you require management approval for access for your research from another institution or organisation then you are responsible for obtaining it. You are reminded that it is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard.

For any enquiries please contact ethics@aut.ac.nz

Yours sincerely,

Kate O'Connor

Executive Manager

Auckland University of Technology Ethics Committee

Cc: ;fraser.watson@stjohn.org.nz; Bridget Dicker; nick.garrett@aut.ac.nz

Appendix B: St John Locality Approval Email

The below email constitutes formal locality authorisation for your study from St John. Please keep a copy of this email for your records.

Date: 10 August 2018

Study title: Outcomes of patients discharged at the scene by paramedics in New Zealand
St John reference: #63

Dear Fraser,

Your research study has undergone a locality review by St John, and I am pleased to inform you that your study is now authorised to go ahead subject to the conditions set out below:

Conditions - general
Progress reports should be submitted to St John annually on 1-May until the conclusion of the project. A link to an online form will be emailed to you when this report is next due for your project.
At the conclusion of the project a final report should be submitted to St John with a synopsis outlining the results, conclusions any recommendations from the study.
The Principal Investigator is required to complete a copy of the *OMF 4.9.7 Research Memorandum of Understanding*, https://www.surveymonkey.com/r/X2VSX5K

Conditions - project specific

- *St John is continually assessing the criteria for non-transported patients, and the non-transport pause and checklist became compulsory in ePRF in December 2017. Care should be taken during the analysis of St John non-transport patients to differentiate patients with red flags, orange flags but with no recommendation seeking further medical care and non-transport based on patient-refusal.*
- *Please contact the following people as your point of contact for this study*
    - *Bridget Dicker (bridget.dicker@stjohn.org.nz) and Verity Oliver (verity.oliver@stjohn.org.nz).*

Yours sincerely,

Verity Oliver

Nga Mihi | Kind regards

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Appendix C: EDACS

Box 3. *EDACS and EDACS-ADP*

EMERGENCY DEPARTMENT ASSESSMENT OF CHEST PAIN SCORE (EDACS)

Clinical Characteristics	Score
a) Age (Please Circle SINGLE Best Answer)	
18–45	+2
46–50	+4
51–55	+6
56–60	+8
61–65	+10
66–70	+12
71–75	+14
76–80	+16
81–85	+18
86 +	+20
b) Male sex (Please circle if true)	+6
c) Aged 18–50 years and either: (i) known coronary artery disease or (ii) ≥3 risk factors	+4
d) Symptoms and signs (Circle each if present)	
Diaphoresis	+3
Radiates to arm or shoulder	+5
Pain† occurred or worsened with inspiration	−4
Pain† is reproduced by palpation	−6
EDACS Total (Please Add all circled figures and enter to right)	_____

EDACS-ACCELERATED DIAGNOSTIC PROTOCOL (EDACS-ADP)

Low risk*	(i) EDACS <16 (ii) No new ischaemia on ECG (iii) 0 and 2 h troponin both negative
Recommendation	Patient safe for discharge to early outpatient follow-up investigation (or proceed to earlier inpatient testing)
Not low risk	(i) EDACS ≥16 (ii) New ischaemia on ECG Either 0 or 2 h‡ troponin positive (see footnote)
Recommendation	Proceed with usual care with further observation and delayed troponin

*Coronary artery disease (CAD) = previous acute myocardial infarction, coronary artery bypass graft or percutaneous intervention. Risk factors = family history of premature CAD, dislipidaemia, diabetes, hypertension, current smoker. †Pain that caused presentation to hospital. ‡A 2 h troponin is only required if other parameters are low risk. ***Safety point**: patients with an unstable presentation (abnormal vital signs or pain that is ongoing or in a crescendo pattern) should not be considered for the low-risk protocol.*

Appendix D: Uncertainty Communication Checklist for Patient Discharge From the Emergency Department

List 2

Uncertainty Communication Checklist for Patient Discharge From the Emergency Department

Introduction

1. Explain to the patient that they are being discharged
2. Ask if there is anyone else whom the patient wishes to have included in the conversation in person and/or by phone

Test results/ED summary

3. Clearly state that either "life-threatening" or "dangerous" conditions have not been found
4. Discuss diagnoses that were considered (using both medical and lay terminology)
5. Communicate relevant results of tests to patients (normal or abnormal)
6. Ask patient if there are any questions about testing and/or results
7. Ask patient if they were expecting anything else to be done during their encounter—if yes, address reasons not done

No/uncertain diagnosis

8. Discuss possible alternate or working diagnoses
9. Clearly state that there is not a confirmed explanation (diagnosis) for what the patient has been experiencing
10. Validate the patient's symptoms
11. Discuss that the ED role is to identify conditions that require immediate attention
12. Normalize leaving the ED with uncertainty

Next steps/follow-up

13. Suggest realistic expectations/trajectory for symptoms
14. Discuss next tests that are needed, if any
15. Discuss who to see next and in what time frame

Home care

16. Discuss a plan for managing symptoms at home
17. Discuss any medication changes
18. Ask patient if there are any questions and/or anticipated problems related to next steps (self-care and future medical care) after discharge

Reasons to return

19. Discuss what symptoms should prompt immediate return to the ED

General communication skills

20. Make eye contact
21. Ask patient if there are any other questions or concerns

Appendix E: Checklists Development Checklist

CHECKLISTS DEVELOPMENT CHECKLIST (CDC)	
1. Focus the checklist task	
☐	Define the content area of interest
☐	Define the checklist's intended uses
☐	Reflect on and draw upon pertinent training and experience
☐	Study the relevant literature
☐	Engage and have conversations with experts in the content area
☐	Clarify and justify the criteria to be met by the checklist (e.g., pertinence, comprehensiveness, clarity, concreteness, ease of use, parsimony, applicability to the full range of intended uses, and fairness)
2. Make a candidate list of checkpoints	
☐	List descriptors for well-established criteria of merit
☐	Briefly define each of the initial checkpoints
☐	Add descriptors for checkpoints needed to round out a definition of merit for the content area
☐	Provide definitions for each of the added descriptors
3. Classify and sort the checkpoints	
☐	Write each descriptor and definition on a separate 4" x 6" card
☐	Sort the cards in search of categories
☐	Identify the main candidate categories and label each category
4. Define and flesh out the categories	
☐	Define each category and its key concepts and terms
☐	Write a rationale for each category
☐	Present relevant warnings about being overzealous in applying the checkpoint
☐	Review the checkpoints in each category for inclusiveness, clarity, and parsimony
☐	Add, subtract, and rewrite checkpoints as appropriate
5. Determine the order of categories	
☐	Decide if order is an important consideration regarding the intended uses of the checklist
☐	If so, write a rationale for the preferred order
☐	Provide an ordering of the categories
6. Obtain initial reviews of the checklist	
☐	Prepare a review version of the checklist
☐	Engage potential users to review and critique the checklist
☐	Interview the critics to gain an in-depth understanding of their concerns and suggestions
☐	List the issues in need of attention
7. Revise the checklist content	
☐	Examine and decide how to address the identified issues
☐	Rewrite the checklist content

8. Delineate and format the checklist to serve the intended uses	
☐	Determine with potential users whether category and/or total scores are needed or desired
☐	Determine with users what needs exist regarding differential weighting of categories and/or individual checkpoints
☐	Determine with users any checkpoints or categories of checkpoints that must be passed for a satisfactory score on the overall checklist
☐	Determine with users what needs exist regarding profiling of checklist results
☐	Format the checklist based on the above determinations
9. Evaluate the checklist	
☐	Obtain reviews of the checklist from intended users and relevant experts
☐	Engage intended users to field-test the checklist
☐	Generally, assess whether the checklist meets the requirements of pertinence, comprehensiveness, clarity, applicability to the full range of intended uses, concreteness, parsimony, ease of use, and fairness
10. Finalize the checklist	
☐	Systematically consider and address the review and field-test findings
☐	Print the finalized checklist
11. Apply and disseminate the checklist	
☐	Apply the checklist to its intended use
☐	Make the checklist available via such means as journals, professional papers, web pages, etc.
☐	Invite users to provide feedback to the developer
12. Periodically review and revise the checklist	
☐	Use all available feedback to review and improve the checklist at appropriate intervals

Appendix F: Surgical Safety Checklist

Table 1. Elements of the Surgical Safety Checklist.*

Sign in
Before induction of anesthesia, members of the team (at least the nurse and an anesthesia professional) orally confirm that:
The patient has verified his or her identity, the surgical site and procedure, and consent
The surgical site is marked or site marking is not applicable
The pulse oximeter is on the patient and functioning
All members of the team are aware of whether the patient has a known allergy
The patient's airway and risk of aspiration have been evaluated and appropriate equipment and assistance are available
If there is a risk of blood loss of at least 500 ml (or 7 ml/kg of body weight, in children), appropriate access and fluids are available
Time out
Before skin incision, the entire team (nurses, surgeons, anesthesia professionals, and any others participating in the care of the patient) orally:
Confirms that all team members have been introduced by name and role
Confirms the patient's identity, surgical site, and procedure
Reviews the anticipated critical events
Surgeon reviews critical and unexpected steps, operative duration, and anticipated blood loss
Anesthesia staff review concerns specific to the patient
Nursing staff review confirmation of sterility, equipment availability, and other concerns
Confirms that prophylactic antibiotics have been administered ≤60 min before incision is made or that antibiotics are not indicated
Confirms that all essential imaging results for the correct patient are displayed in the operating room
Sign out
Before the patient leaves the operating room:
Nurse reviews items aloud with the team
Name of the procedure as recorded
That the needle, sponge, and instrument counts are complete (or not applicable)
That the specimen (if any) is correctly labeled, including with the patient's name
Whether there are any issues with equipment to be addressed
The surgeon, nurse, and anesthesia professional review aloud the key concerns for the recovery and care of the patient

* The checklist is based on the first edition of the WHO Guidelines for Safe Surgery.[15] For the complete checklist, see the Supplementary Appendix.

Appendix G: Development of the WHO Safe Surgery Guidelines

WHO recommended steps in technical guideline development	Action Taken
Define the specific issues to be addressed by the guidelines	Completed
Undertake a systematic search for evidence	Completed
Review the evidence available	Completed
Develop recommendations linked to the strength of the evidence	Completed
Draft guidelines	Completed
Discuss and incorporate, where relevant, comments of external reviewers	Completed
Draft final version of the guidelines	Completed
Make recommendations on dissemination strategy	Completed
Document the process of guideline development	Completed
Test the guidelines through pilot evaluations	Completed

World Health Organization (2009).