IMPROVING TRAUMA CARE IN BRITISH COLUMBIA USING EARLY ACTIVATION OF HELICOPTER EMERGENCY MEDICAL SERVICES

by

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ABSTRACT

Utilizing helicopter emergency medical services (HEMS) to minimize the time from injury to definitive trauma care is increasingly popular in North America. Through a combination of improved access, expeditious transport, and superior preclinical therapy, multiple studies have demonstrated that direct transfer by HEMS from the emergency scene to a level-1 trauma center significantly reduces mortality.

Early activation of HEMS, or Autolaunch, to emergency scenes prior to the arrival of ground ambulances based on information provided by 9-1-1 callers is an innovative way of reducing response times further. Information extracted from these callers enables the dispatcher to simultaneously send HEMS and ground-EMS directly to the scene.

This work presents a study that examined the changes in response times to major trauma patients in southwestern British Columbia since the Autolaunch strategy came into effect in 2004. This study highlights significant reductions in response times when Autolaunch is used.

Keywords: Helicopter; Emergency; Autolaunch; Dispatch; Trauma; Transport; British Columbia.

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1: INTRODUCTION

Trauma is one of the leading causes of morbidity and mortality worldwide yet it remains an underrepresented public health concern (Campbell et al., 2009; WHO, 2008). Public health professionals have an important role to play in preventing disability and death from trauma because its causes are often predictable and preventable. The best way to reduce trauma related morbidity and mortality is through primary prevention (Evans, 2007; PHWG, 1999); however, when primary prevention fails, emergency medical services (EMS) respond rapidly and in an orchestrated manner to provide immediate lifesaving treatment and then transport patients to the appropriate hospital for definitive treatment (CDC, 2009). The goals of this "complex mosaic of immediate emergency care" (Judge, 2007, p.237) are to minimize the time to definitive treatment (ie. surgery) and improve health outcomes (Shepherd, Trethewy, Kennedy & Davis, 2008). The landmark 1966 document Accidental Death and Disability: The Neglected Disease of Modern Society first popularized the need and potential benefits of organized trauma care to accomplish these goals (Báez, Lane, Sorondo & Giraldez, 2006; Gaston, 1971; Higgins & Kerstein, 1995; NRC, 1966).

Utilizing helicopter emergency medical services (HEMS) to minimize the time to definitive treatment is increasingly popular in North America (Bledsoe & Smith, 2004). In the context of regionalized health care—in British Columbia

(BC) for example—HEMS have been described as the "glue" between disparate entities of the health care system (Judge, 2007). Multiple studies have shown that HEMS results in expedited transport and reduced mortality of major trauma patients (Biewener, Aschenbrenner, Rammelt, Grass & Zwipp, 2004; Boyd, Corse & Cambell, 1989; Cudnik, Newgard, Wang, Bangs & Herrington IV, 2008; Mitchell, Tallon & Sealy, 2007; Sampalis et al., 1997; Thomas, Wedel, Buras & Harrison, 2000). Others have examined differences in ground versus air transport of major trauma patients and have indicated that when HEMS is used the time to definitive care is lessened and mortality is reduced (Berns, Caniglia, Hankins & Zietlow, 2003; Falcone, Herron, Werman & Bonta, 1998); however, until now no Canadian studies have analyzed the efficiency of dispatching HEMS to scenes of major trauma based on non-medical witness (bystander) information. This process of early activation, prior to the arrival of ground ambulance, is called Autolaunch.

Autolaunch is an EMS dispatching strategy that is activated through the 9-1-1 medical priority dispatch system (MPDS). MPDS is a computerized dispatch program that assists EMS dispatchers in the prioritization of emergency calls and allocation of resources to emergency scenes (Cady, 1999). Based on information provided by 9-1-1 callers the MPDS program prompts the dispatcher to consider initiating Autolaunch. By definition Autolaunch means to automatically and simultaneously launch the air-ambulance and ground-EMS to the accident scene based on information provided by non-medical witnesses or non-medical first arrivals to the scene (ie. 9-1-1 callers) (Berns et al., 2003;

L'Heureux, 2004). Prior to 2004 in BC, the traditional dispatch strategy sent ground-ambulances to the scene first. Once paramedics were on scene they would assess the patient(s) and determine if the air-ambulance was needed.

Despite the widespread use of Autolaunch there are concerns about its inappropriate use; this includes minor trauma (over-triage) and "missed" opportunities for HEMS transport of major trauma (under-triage) (Wish & Davis, 2005). In light of the rising cost of transport and the increasing crash frequency the organizations that utilize HEMS are under a growing pressure to support this dispatch strategy with evidence that demonstrates efficiency and improved health outcomes for victims of major trauma (Belway, Henderson, Keenan, Levy & Dodek, 2006; Bledsoe & Smith, 2004).

The purpose of this paper is explain how early activation of HEMS are being used to improve trauma care in British Columbia (BC) by expediting treatment and transport of the severely injured. The central question addressed here is "how have HEMS response times to major trauma patients changed since the inception of Autolaunch?"

This paper is divided into four parts. Part one details the trauma system in BC and provides an epidemiological overview of trauma; part two provides a literature review of HEMS; part three explains an Autolaunch study being undertaken by Wheeler et al. (2009) that analyzed changes in response times since Autolaunch began; part four concludes with policy and practice recommendations based on these findings.

2: CONTEXT

2.1 Epidemiological review of trauma

Trauma is a severe form of injury that results from an external force being applied to the human body (VCH, 2007). For example, blunt force trauma from motor vehicle crashes, or penetrating trauma from knives or bullets. These external forces have the potential to cause severe anatomical and physiological injuries that require timely diagnosis and treatment to prevent disability or death.

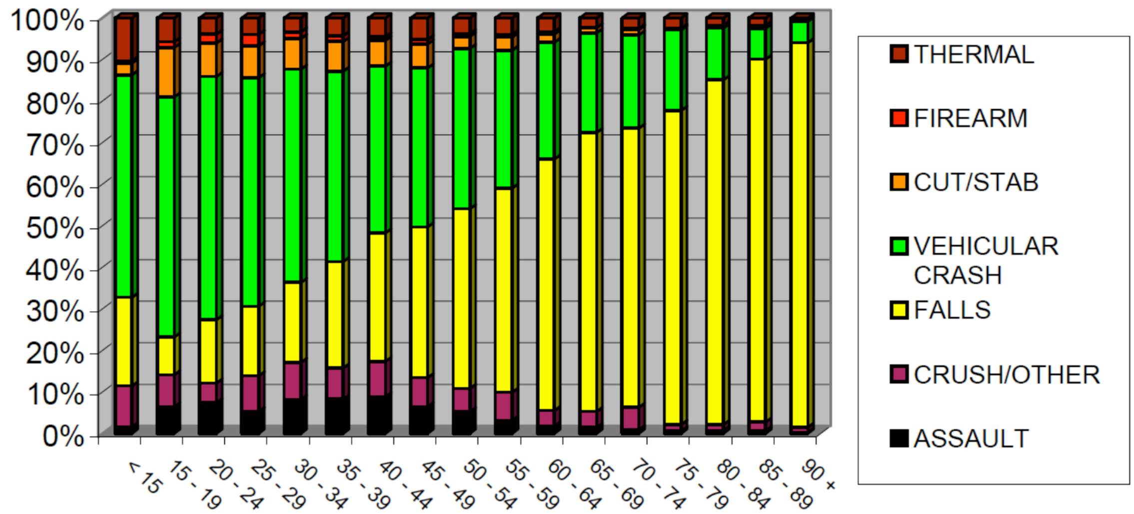
On a global scale, trauma causes more than five million deaths each year, most of which (~90%) occur in low and middle-income countries (Mock, Arafat, Chadbunchachai, Joshipura & Goosen, 2008). Trauma resulting from road traffic accidents is the ninth most common cause of mortality worldwide (WHO, 2008). These mortality statistics only speak to a fraction of the impact from trauma because for every recorded death due to injury many more are left disabled (Girolami & Little, 1999). Canadian epidemiologist John Last who coined the phase “iceberg effect” in 1963 explored the relationship between injury and disability, concluding that deaths and hospitalizations due to injury are simply the “tip of the iceberg” because the post-injury impacts such as disability remain “submerged” (Sahai, Ward, Zmijowskyj & Rowe, 2005).

In Canada, injury is the leading cause of death among those under the age of forty-five. From 2004-2005 there were 196,865 hospitalizations due to injury that resulted in 1,943,660 days in hospital (mean length of stay = 10 days). Of these cases, 11,112 were classified as trauma (injury severity score > 15) that resulted in 172,790 days in hospital (mean LOS = 16 days). Of the 11,112 admitted, 13% (n = 1,428) died either in the emergency department or later in the hospital. Primary causes included motor vehicle collisions (45% n = 4,955) and unintentional falls (32%, n = 3,561). The combined cost estimate for direct and indirect costs of these injuries is $12.7 billion annually (NTR, 2006; CIHI, 2007; Evans, 2007).

A majority of trauma deaths in BC are attributable to motor vehicle collisions (MVCs) which predominantly affect people less than 65 years old (VCH, 2007) (Figure 1). The Interior Health Authority (IHA) and Northern Health Authority (NHA) experience a disproportionate number of deaths due to MVCs when compared to the more urbanized health authorities (Figure 2). Time to definitive care may be a contributing factor. In BC overall the northern and interior health regions experience the highest incidence of trauma (Schuurman, Hameed, Fiedler, Bell & Simons, 2008). The incidence of MVCs is expected to rise as motor vehicle density increases with urbanization and the World Health Organization predicts that on a global scale motor vehicle accidents may become the third largest contributor to disability and the fifth largest contributor to death by 2020 (Girolami & Little, 1999; Murray, 2006; WHO, 2008).

Figure 1

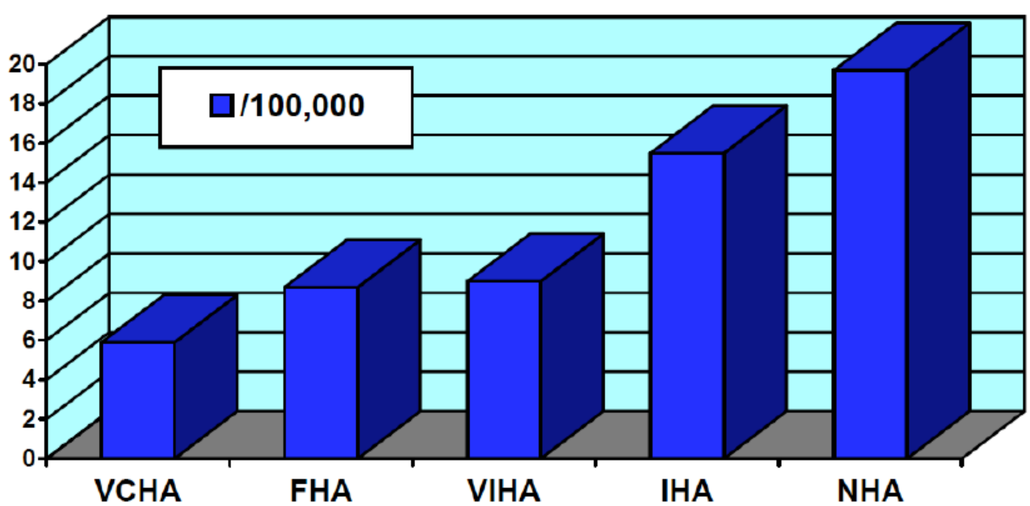
Percentage of Injury Admissions within Vancouver Coastal Health by Mechanism and Age 2006-2007



Source: (BC Trauma Registry data, as cited in VCH, 2007)

Figure 2

Death Rates Due to Motor Vehicle Collisions by Health Authority 2006

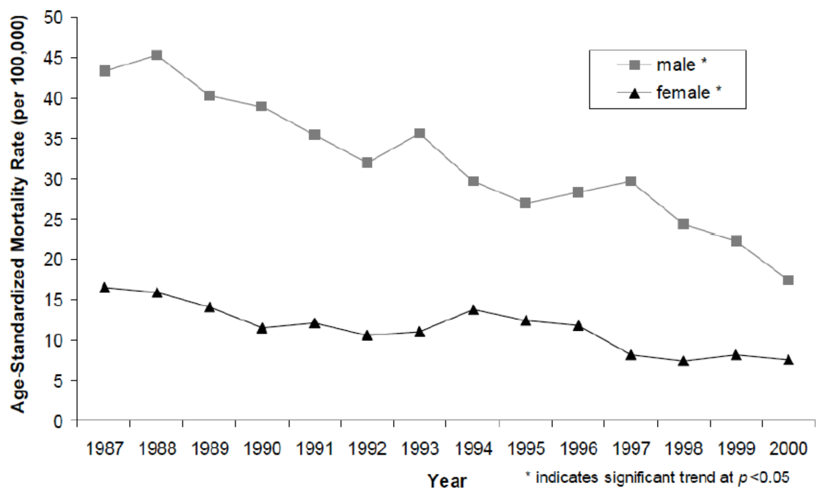


VCHA: Vancouver Coastal Health Authority; FHA: Fraser Health Authority; VIHA: Vancouver Island Health Authority; IHA: Interior Health Authority; NHA: Northern Health Authority
Source: (BC Coroner 2006, as cited in VCH, 2007)

BC trends for age-standardized mortality rates for males and females aged 0-24 from injury have been on a steady decline since 1987 (Figure 3) (Rajabali et al., 2005). This is attributed to primary prevention as well as improvements in clinical treatment. Data from the BCTR show specific improvements in blunt trauma survival of patients treated at Vancouver General Hospital (VCH, 2007).

Figure 3

Trends for Age Standardized Mortality Rates, All External Causes of Injury, by Gender, Ages 0-24 years, in B.C., 1987-2000



Source: Rajabali, et al. (2005).

2.2 Review of the trauma system

British Columbia has a regionalized health care system that is divided into five geographically distinct health authorities and one provincial health authority that manages shared resources (Figure 4).

Regionalization is a way of organizing the health system to integrate and consolidate scarce health resources within each health authority. It is also a way of "categorizing hospitals by the level of critical care they can provide and then routinely transferring critically ill patients to high-level referral hospitals" (Kleinman, 2009, p.2303). Organizing the health care system in this way has been shown to decrease preventable death and improve trauma outcomes (Báez et al., 2006; Brooks, Burton, Williams & Mahoney, 2001; Falcone et al., 1998; Higgins & Kerstein, 1995; Mc Murty, Nelson & de la Roche, 1989).

Figure 4

British Columbia Health Authorities

Source: http://www.bcbudget.gov.bc.ca/2007/sp/hlth/img/hlth_app_1_map.gif

There are many well-known benefits of regionalization, however, one of the inherent consequences of this design is the vast distance that some patients need to travel to receive definitive care—this is especially relevant for people in northern BC because two thirds of the population resides in the southwest corner of the province where specialized services have been centralized. Multiple studies, including one by Hamilton (2002) that used BC Coroner data found that distance and time to definitive care are contributing factors to increased mortality in rural settings. For example, Hamilton found that 12% of all trauma deaths in the lower mainland were pre-hospital deaths; whereas on Vancouver Island 45% died prior to reaching a hospital, 59% in the interior, and in 75% in northern BC (Hamilton, 2002; Shepherd et al., 2008). Dismal health outcomes like these are the reason that minimizing the time from injury to definitive care is a priority of the trauma system.

The trauma system is a subset of the overall health system. It is an organized continuum of care that includes pre-hospital and intra-hospital activities that exists within and across all health authorities. The trauma system "provides an integrated network of hospitals of various capabilities to ensure that all populations receive responsive, accessible and appropriate care, that the most severely injured patients receive comprehensive care at high volume trauma centers, and that resources are optimized" (Shuurman, 2009, p.1). Connecting these resources is made possible by the British Columbia Ambulance Service (BCAS). BCAS utilizes 470 ground ambulances and nine dedicated aircraft (three helicopters and six planes) (BCAS, 2008). Fixed wing air-ambulance (airplanes) have been used since the ambulance service began in 1974, whereas HEMS were not used regularly until the spring of 1993. Since that time, there has been a growing emphasis on using HEMS for pre-hospital trauma care and the use of early-activation response strategies like Autolaunch, which officially began on July 1 2004.

Pre-hospital EMS are usually initiated by emergency calls to 9-1-1 followed by dispatch of ground and/or air-ambulances. Once on scene the paramedics triage, treat, and transport patients to receiving hospitals where the trauma-team is waiting (IOM, 2007). The trauma team is comprised of a physician trauma-team-leader, specially trained nurses, and other multidisciplinary staff and specialists. Having a dedicated hospital team like this has been shown to significantly reduce mortality in patients with moderate or severe injuries (Brooks et al., 2001; Petrie at al, 2007).

Trauma patients are normally transported to the highest level of care available—a level-1 trauma centre. The designation of level-1 trauma centre means that they have acquired the specialized resources and personnel that are required to care for the severely injured (CDC, 2009). Trauma receiving hospitals for HEMS in southwestern BC include: Victoria General, Vancouver General, Royal Columbian, and BC Children's. BC first introduced this system of designated trauma hospitals in 1991 and since then has demonstrated a significant improvement in patient outcomes (Evans, 2007). The BC Trauma Registry (BCTR) has tracked these improvements and continues to collect and analyze provincial trauma data (VCH, 2007); moreover, this comprehensive data helps plan injury prevention programs and inform clinical research.

2.3 Application of Helicopter Emergency Medical Services in BC

Reaching emergency scenes is often difficult and sometimes impossible by ground-EMS, therefore, helicopters offer a viable alternative. Transport and immediate care of trauma patients in BC is complicated by topography, weather, and sparse population distribution. The farther north or more rural one goes, the greater these challenges are (Hamilton, 2002).

Every province and territory in Canada utilizes air-ambulances. Helicopters are predominantly used for transports less than three hundred kilometers, whereas, longer transports are more efficiently accomplished using airplanes. Distance is often used as a guideline for response modality; however, one Australian study indicated that distance is a poor indicator of time to definitive care because the time to cover a certain distance is variable depending on available resources, terrain, accessibility of the scene, and mode of transport (Danne, 2003). Therefore time rather than distance has become the standard for dispatch decisions in BC. This strategy is becoming increasingly useful for dispatchers when they consider the impact that traffic congestion and other dynamic barriers to the efficient transport of trauma patients in and around greater Vancouver (L'Heureux, 2009).

Understanding the balance between need and demand for HEMS is hampered by a lack of data on the exact number of HEMS being used in Canada, however, data from the BCAS indicates a 4% average annual increase in demand for HEMS since 2004 (BCAS, 2008). Demand projections will need to take into consideration the changes to demography and distribution of the population, changes in aviation and medical technology, and increasing centralization of specialized services. These influences are expected to double the demand for medical transport (Judge, 2007).

Patients who are most severely injured and those who are farther from trauma centres experience the greatest benefits from HEMS, especially those suffering from blunt trauma (Davis et al., 2005; Frankema et al., 2004; Hawkins, Morgan, Waller, Winslow & McCoy, 2001; Shepherd et al., 2008; Thomas, 2007). Knowing this, BCAS developed a dispatch strategy for the early activation of HEMS called Autolaunch. The goals of Autolaunch are twofold; first is to reduce the time from injury to definitive care by having major trauma patients (injury severity score [ISS] >15) transported by HEMS directly to trauma receiving hospitals if the driving distance is > 20 minutes; and second to reduce activation times (time from 9-1-1 call to dispatch of HEMS) by dispatching the HEMS based on information provided by the 9-1-1 caller (L'Heureux , 2004). All Autolaunch flights must meet one of the activation criteria and/or flight continuance criteria outlined in Table 1. This strategy has been used in the southwest corner of BC since July 1, 2004 and serves the lower mainland and Vancouver Island. Two full-time helicopters are positioned at Vancouver International Airport's south terminal and are staffed from 0900-2100. Between the hours of 2100-0900 paramedics from a neighboring station will respond on-call. This response area covers over 2.7 million persons, or approximately 60% of the population in BC (Figure 5) (Schuurman, Bell, L'Heureux & Hameed, 2009).

Table 1

Autolaunch Activation and Flight Continuance Criteria

Injury / mechanism
Drowning / Diving
Drowning / SCUBA
Electrocution, Lightning *Unconscious
Industrial / Machine Accidents Entrapped
Traffic / Transportaion /Pinned/ *Unconscious
Traffic / Transportation/ High Mechanism/ *Unconscious
Stab/Gun shot wound/Penetrating Trauma (Wound above knee or elbow)
Stab/GSW/Penetrating Trauma *Unconscious
Fall / Long Fall and *Unconscious
Burns / Unconscious
Burns / Explosion
Burns >10% 3rd degree
Burns >20% 2nd degree
CO / Inhalation *Unconscious
Drowning *Unconscious
Additional Criteria
GCS less than or equal to 13
BP < 90 Signs of Shock
2 or more proximal #'s
20% 2nd degree burns
High Voltage Burns
Respirations <10 >30
Penetrating Injury Chest, Head, Abdomen, Groin, Proximal Extremity
Major extremity Amputation
10% 3rd degree burns
Facial/Airway Burns
3rd degree burn of Eyes, Neck, Hands, Feet or Groin Burns / Explosion

Figure 5

British Columbia HEMS Autolaunch Response Area 2006-2009

3: LITERATURE REVIEW

3.1 Overview

The Centers for Disease Control (CDC) and the World Health Assembly have taken the lead in describing the global burden of trauma and the need to strengthen pre-hospital emergency care. For example, in 2007, the World Health Assembly adopted the ''Health Systems: Emergency Care Systems'' resolution 60.22 which called on governments worldwide to adopt a variety of measures to strengthen trauma and emergency care services. In line with this, the North American CDC published specific recommendations on the pre-hospital or "field-triage" of trauma patients. Filed-triage is a process whereby EMS providers determine the extent of injury, initiate medical management, and identify the most appropriate receiving hospital. The CDC guidelines are comprehensive and detailed but the main message is clear—when in doubt, transport to a trauma center (CDC, 2009). Autolaunch streamlines this field-triage process by having pre-designated trauma centres that are obliged to accept inbound trauma patients.

The CDC recommendations are informed by numerous studies that have demonstrated the importance of accessing care within the first hour after injury. The "golden hour" as it's called, has been a fundamental tenet of trauma system planning for thirty years because patients who receive definitive in-hospital treatment within the golden hour have much higher survival rates (Báez et al., 2006; Berns et al., 2003; Edelman, 2007; Higgins & Kerstein, 1995); moreover, Báez, Lane, Sorondo, and Giraldez (2006) found that total response time—that is the elapsed time from injury to arrival at the hospital—correlates significantly with length of stay in hospital and complications in young patients (< 65 years) (Báez et al., 2006).

There is a growing concern in the literature about what constitutes definitive care. Some researchers have suggested that the critical care paramedics of HEMS represent an element of definitive care at the emergency scene; however, opinions about how long HEMS should stay on scene to provide these treatments remains controversial (Gwinnutt, Bethelmy & Nolan, 2003; Mogo & Harstall, 2008; Nicholl, Brazier & Snooks, 1995; Ringburg et al., 2009). The specific impact of HEMS on-scene treatment on health outcomes is an area of future concern that that warrants further investigation.

As mentioned, regionalization is one of the main reasons why HEMS transport is needed. One of the dilemmas of a regionalized design is that static resources such as hospitals experience most of the cost savings; whereas, costs are increased for ambulance services that travel farther to reach centralized services (McDonald, 2006).

The balance of needs, demands, and cost are in constant tension for HEMS providers (Judge, 2007). Various metrics have been developed to assist in the validation of HEMS programs, the most popular being the calculation of under and over-triage rates.

Over-triage occurs when the HEMS was dispatched but is subsequently cancelled by ground EMS because the patient(s) suffered only minor injuries, or when HEMS transported a patient with an ISS < 15 or was discharged from the hospital in less than 48 hours (ie. minor injury).

Under-triage is theoretically a “missed” opportunity for HEMS. This means that a trauma patient was transported by ground-EMS or another form of transport within the Autolaunch response area. If the severity of a patient’s injuries were not apparent to the dispatcher during the initial 9-1-1 call, Autolaunch would not be activated; notwithstanding these instances, many other reasons for under-triage exist. For instance, a patient may have been transported by ground-EMS while HEMS were flying to the scene, or the HEMS were dedicated to another flight (ie. inter-hospital ICU transfer) and unable to respond. To understand if under-triage was the result of inefficient dispatch criteria an analysis of the sensitivity and specificity of each dispatch criterion (ie. entrapment, ejection from vehicle, or loss of consciousness) could be done to determine which, if any, of the dispatcher’s questions to the 9-1-1 callers result in under-triage (Ringburg et al., 2009).

The American College of Surgeons Committee on Trauma recently defined an acceptable under-triage rate as 5%, whereas over-triage rates may be as high as 25% to 50% (Purtill et al., 2008). Validating HEMS in this way is of critical importance to improving the dispatch criteria of HEMS and overall trauma care in British Columbia. HEMS dispatch criteria needs to be highly efficient because air transport represents a concentrated allocation of scarce health care resources (Ringburg et al., 2009).

3.2 Effectiveness of Helicopter Emergency Medical Services

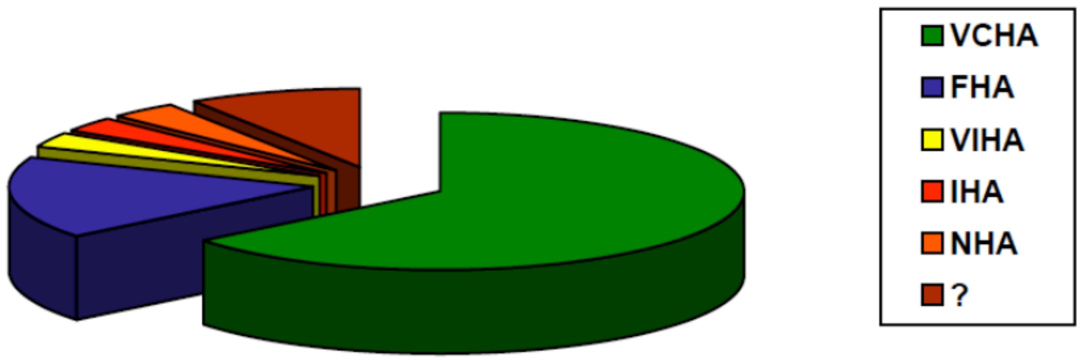
Multiple studies have demonstrated that direct transfer by HEMS from the emergency scene to a level-1 trauma centre significantly reduces mortality (Berlot et al., 2009; Biewener et al., 2004; Boyd et al., 1989; Cudnik et al., 2008; Mitchell et al., 2007; Sampalis et al., 1997; Thomas et al., 2000). HEMS are able to accomplish this through a combination of improved access, expeditious transport, and superior preclinical therapy. Utilizing delegated-medical-functions in cooperation with physician advisors HEMS paramedics typically have some physician level capabilities exceeding those of ground-EMS providers (FARE, 2006).

Intuitively, helicopters offer a faster mode of transport. This hypothesis has been tested, and in the context of HEMS a simultaneously dispatched helicopter gets patients to the hospital faster, so long as the distance is greater than 10 miles (Diaz, Hendey & Bivins, 2005). If it were less than 10 miles, ground-EMS is faster. Delimiters based on distance are unreliable and can lead to the inappropriate use of HEMS in metropolitan areas (Shatney, Homan, Sherck & Ho, 2002). Additionally, many “grey zones” exist at the boundaries of the HEMS response areas surrounding cities. For example, it may be unclear for a dispatcher to Autolaunch HEMS to the scene of an accident that takes place within the city limits of Vancouver, Victoria, and Nanaimo. Dispatchers are becoming increasingly aware of the transport barriers in our urban environments and the rapid response times of ambulances in those areas. As a general rule, HEMS is not dispatched to the downtown core of these cities, but as this decision-making becomes more complex, more sophisticated geo-modeling procedures that encompass a wider environmental perspective should be used to inform HEMS placement and dispatch decisions (Leppaniemi, 2009; Schuurman et al., 2009; Schuurman et al., 2008).

In addition to swift transport, a key principle of EMS is delivery of the patient to the most appropriate facility. The CDC reports that the risk for death of a severely injured person is 25% lower if the patient receives care at a level-1 trauma centre (CDC, 2009). HEMS Autolaunch in BC has been designed around this understanding so that all major trauma patients are transported directly to level-1 trauma centres. There is also an appreciation that with regionalization comes a disparity in available health resources for remote communities. HEMS plays an important role in reducing health inequalities in rural areas, by bringing rurally located patients to the best available trauma care in the province. A review of data from Vancouver General Hospital reveals that approximately one third of admitted trauma patients were from health authorities outside the lower mainland (Figure 6) (VCH, 2007).

Figure 6

Trauma Patient Origin by Place of Residence 2006-2007



Source: VCH (2007)

In a publicly funded health care system like Canada there is a constant need to prove the efficacy and cost-effectiveness of any health care intervention (Cox, Laupland & Manns, 2006; Mitchell et al., 2007). One of the common misconceptions about HEMS is that its costs cannot be justified. While HEMS may appear to be expensive on a single-case basis compared with ground ambulance service, on a system-wide basis it is cost-effective (FARE, 2006; Hankins, 2006). A realistic calculation of the "costs" of HEMS requires an appreciation for the cost of alternative transport (Ringburg et al., 2009). In BC this means possibly transporting a patient with multiple ambulances through various community hospitals along the way to definitive care. For example, before Autolaunch, if a person was injured in Port McNeill on Vancouver Island they would first be brought to the Port McNeill hospital by ground-EMS, then driven by another ambulance south to Campbell River and then again to Nanaimo hospital; conversely, they may have been flown these legs of the journey; then if they required specialized care (ie. spinal, vascular, pediatric) they may need to be flown again to Victoria or Vancouver for definitive care. The Autloaunch pilot study by L'Heureux (2004) found that in some cases the Autolaunch dispatch strategy reduced the number of flights from six to one. Studies of Alberta's "STARS" air-ambulance also indicate that HEMS is both efficient and cost effective (Powell et al., 1997).

Despite the many benefits of HEMS controversy remains as to its effectiveness and deployment. A review of air ambulance transfer data revealed that one third of trauma cases delivered to Vancouver General Hospital suffered single system injuries. It is the view of Hamilton (2002) that "most of these patients could be managed more efficiently in their own region with less delay to definitive treatment and with much less expense to the health care system" (Hamilton, 2002, p.7). This statement is somewhat of an overgeneralization because some "single system" injuries like vascular or neurological injuries require specialized services not found in all areas of the province. The purpose of advancing HEMS research is to ensure that each patient receives the specialized care that they require, in the least amount of time, so that health outcomes are improved and costs are minimized.

3.3 Data Gaps & Limitations

The disharmony amongst trauma data sources creates unnecessary barriers that stall research progress and make longitudinal trauma research a difficult task. In light of this, the Canadian Association of Emergency Physicians have publicly criticized Canada's embarrassingly unsophisticated collection of local, unlinked, and non-standardized data repositories that impairs our ability to assess the quality of emergency care and measure health outcomes (CAEP, 2009).

The BC Trauma Registry (BCTR) is BC's primary data repository. It gathers comprehensive demographic and health information on patients who meet the selection criteria outlined in Table 2.

Table 2

BC Trauma Registry Adult Inclusion & Exclusion Criteria 2007-2009
Adults (>15 years of age) admitted to a Trauma Registry facility for treatment of a trauma diagnosis caused by external causes **AND** have been admitted within 21 days of sustaining the injury **AND** have an admission with a length of stay > 48 hours
OR, all transfers, into or out of the Trauma Registry facility for the purposes of providing trauma care. **OR,** all deaths including those patients pronounced dead on arrival, those pronounced dead in the Emergency Department (even if no intervention performed) and those pronounced dead after receiving any evaluation or treatment during the hospital admission
Excluded are all elderly patients (≥ 65 years of age) with isolated hip fractures from same level falls with an ISS ≤ 9 **Also Excluded** • Psychiatric admission for self-inflicted injuries (i.e. underlying psychiatric disorder cause of admission, NOT traumatic injuries). • Drowning with no associated anatomical injuries. • Falls / injuries – admission for underlying problem (seizure, syncope, general debility, weakness) rather than for injuries sustained. • Foreign body in hollow viscus – esophagus, rectum, etc. • Chronic subdural or epidural bleeding. • Pathological fractures. • Cellulitis / infection / abscess arising as complications of lacerations, animal bites, etc. • Poisonings / overdoses. • Decompression sickness. • Fractures that are old or indeterminate if patient had a fall.

Not all trauma patients are captured by the BCTR. For example, the most severely injured who die prior to hospital admission or in the field are not reviewed by the BCTR. This contributes to significant gaps in the data that would account for the most severe injuries that contributed to death. This data is available from the BC Coroner, however no formal research partnerships exist to this end. Not only are patients who die prior to hospital admission not captured by BCTR, neither are those who die after discharge. This is a significant gap because in one Australian study 25% of trauma deaths occurred after discharge from hospital (Hall, Dobb & Hall, 2001). The ongoing Autolaunch study by Wheeler et. al (2009) outlined below should consider these data gaps when health outcomes such as morbidity, mortality, and disability are analyzed. Bridging pre and post-hospital health data through partnerships with the BC Coroner and the National Ambulatory Care Reporting System (NACRS)—a database that tracks non-hospital-based clinical treatments such as doctor's offices—could provide a broader understanding of the health outcomes from major trauma.

Even once the data are collected there are limitations in the metrics, tools, and models that are derived from them. The most well known metric, the Trauma Injury Severity Score (TRISS), is a logistic regression model that is used to predict the probability of survival. Components of the TRISS include the Injury Severity Score (ISS), Trauma Score (TS), and age that attempt to conceptualize the extent of anatomical injury, physiologic response, and physiologic reserve respectively. Each of these components has documented weaknesses.

The ISS for example describes the extent of physical injury by assigning a score from 1 (minor injury) to 6 (major injury) across six body systems. Each of these scores is called an abbreviated injury score (AIS). An example of the thoracic AIS score is shown in Figure 7. Once the AIS score for each body system has been determined the three highest scores are squared and then summed. The maximum score is 75. A score > 15 is predictive of 10% mortality and defines trauma based on anatomical injury. If any one body system scores a 6, the ISS automatically becomes 75. Two of the major pitfalls of the ISS is its ability to sufficiently account for multiple injuries one body system and to convey the extent of penetrating injuries (Boyd, Tolson & Copes, 1987; Tay, Sloan, Zun & Zaret, 2004).

Figure 7

Thoracic Section of the Abbreviated Injury Score

AIS	Severity	Injury Description
1	Minor	Rib contusion/fracture* Sternal contusion
2	Moderate	2-3 rib fractures, stable chest* Multiple fractures of single rib* Sternal fracture
3	Severe, not life threatening	Rib fracture open/displaced/comminuted* >3 rib fractures, stable chest*
4	Severe, life threatening	Flail chest (unstable chest wall)
5	Critical	Severe flail chest (usually requires ventilatory support.
* Add 1 for presence of hemothorax, pneumothorax, hemo or pneumomediastinum		

Source: Boyd, Tolson & Copes (1987)

The Trauma Score takes into account physiologic metrics such as blood pressure, capillary refill, respiratory rate, respiratory effort and Glasgow Coma Score (GCS) and produces a cumulative score (Appendix A). The Trauma Score is used to calculate the probability of survival (Table 3). Although the Trauma Score is 80% sensitive, it fails to capture those 20% of patients who are physiologically compensating for their injuries (Boyd et al., 1987).

Table 3

Trauma Score and Probability of Survival

Trauma Score	Probability of Survival
16	99%
15	98%
14	95%
13	91%
12	83%
11	71%
10	55%
9	37%
8	22%
7	12%
6	7%
5	4%
4	2%
3	1%
2	0%
1	0%

Source: Boyd, Tolson & Copes (1987)

Age is the third component of the TRISS. It is used in as a surrogate for cardiovascular compromise. Basically, the formula will consider whether or not a patient is 55 years or older. Doing so adjusts for the increased mortality rates observed in the population. A theoretical example of the TRISS is provided in Appendix B.

Overall the TRISS has major documented limitations including insufficient control for physiological reserve; missing physiological data; problems inherent to the injury severity score; poor model calibration; and weights based on an outdated, biased sample from the Major Trauma Outcome Study from 1982-1987 (Moore et al., 2009; Mauritz et al., 2000; Ringburg et al., 2007). Furthermore, the TRISS cannot be considered in isolation from the continuum of care; at best it represents one moment in time. To gain a better understanding of the patient's response to therapy and transport Rodenberg (1996) suggests that it be calculated at various intervals throughout the course of treatment.

3.4 Literature Gaps

Canada suffers from a tremendous dearth of aeromedical research and decision makers often look to foreign studies to guide policy and practice. Given the variability of contextual factors such as crew configuration, aircraft technology, and tertiary care infrastructure, as well as environmental factors like population distribution and demographics, urban development, and topography, study results can only be cautiously generalized.

Future research needs to be done with the provider in mind. Too often HEMS research focuses on retrospective analyses such as the TRISS that have little to offer the dispatchers or paramedics involved in the day-to-day decisions about HEMS deployment. Paramedics and dispatchers are concerned with decisions about treatment, transport, and dispatch modalities. In the end these phenomena influence trauma outcomes and triage-rates and require further analysis to improve the trauma system (Petrie et al., 2007).

One of the most significant literature gaps is of long-term health outcomes and trauma patients who were treated and transported by HEMS. It is not sufficient to simply explain that HEMS is fast and efficient—studies should describe health outcomes in addition to survival rates and probabilities. Future studies need to incorporate a robust analysis of long-term health outcomes by linking with non-hospital based data sources. The National Ambulatory Care Reporting System will be a valuable source of data for such analyses (Sahai et al., 2005).

4: BC AUTOLAUNCH STUDY

4.1 Background

In May of 2009 members of the BC Trauma Advisory Committee including Dr. Stephen Wheeler and Dr. Richard Simons, partnered with the BC Trauma Registry, BCAS, Simon Fraser University (SFU), and local health authorities to evaluate the impact of HEMS Autolaunch in southwestern BC. This study built on the findings of an auto-launch pilot study conducted in 2004 on Vancouver Island that showed response times were reduced and that over-triage was minimal (L'Heureux, 2004). Since that time Autolaunch has expanded across the southwestern corner of the province and includes a much larger catchment area involving four health authorities (Vancouver Island, Vancouver Coastal, Fraser, and Provincial Health Services). The results of this study will both evaluate the efficacy and efficiency of the current Autolaunch dispatch strategy, as well as inform the development of Autolaunch in other sectors of the province. The principle investigator for the BC Autolaunch study is Dr. Stephen Wheeler.

4.2 Ethics

The VIHA and SFU conducted an ethical review and granted approval for the Autolaunch study that commenced on July 31, 2009.

4.3 Study Design

The study design was a retrospective trauma database review.

4.4 Time Frame

Four years of patient data was reviewed: July 1 2002- June 30-2004 and June 15 2006- June 15 2008. These two intervals represent time periods prior to and after implementation of Autolaunch.

4.5 Purpose

The primary purpose of this study was to identify the changes in response times to major trauma patients since the inception of the Autolaunch program in British Columbia. Wheeler et. al (2009) hypothesized that Autolaunch has reduced response times to severely injured patients and the overall time to definitive care. The primary research question was, "how have HEMS response times to major trauma patients changed since the inception of Autolaunch July 1, 2004?"

4.6 Methods

Data were obtained from the BC Trauma Registry (BCTR) and the BCAS. Data collection included demographic, anatomical, physiological, and event related information for all trauma patients who were transported by air during the study time periods (Appendix C). Two cohorts were created, one from the first date interval prior to Autolaunch (July 1, 2003 and June 15, 2006) and one from the second interval of when Autolaunch expanded following the pilot study (June 15, 2006 and June 15, 2008). Trauma for the purposes of this study was an injury severity score (ISS) > 15. All adult trauma patients (ISS >15) who were transported by BC HEMS within the Autolaunch response area and study time frames were included.

Statistical analysis of the data was done using SPSS for Mac (Ver.17). Levine's Test for equality of variances was used to assess homogeneity-of-variance and the Student's t-test was used for the assessment of associations between the time intervals of interest (Table 4). For all tests statistical significance was set at ≤0.05. To satisfy the assumptions of the Student's t-test, descriptive statistics including the means, standard deviations, and variances were compared to verify the normality of data and assess the homogeneity of variance.

Table 4

Response Interval Descriptions

Response Interval	Description
Activation Time	Time interval from injury to dispatch of helicopter emergency medical services
Time to definitive care	Total time from injury to patient arrival at receiving hospital

4.7 Results

During the study period Vancouver based HEMS Autolaunch was requested 524 times. 194 of these requests resulted in cancellations (Table 5). This means that either the ground-EMS unit or another medical first-responder determined that HEMS was not required. Of the 524 requests 330 resulted in completed Autolaunch flights. The mean injury severity score of the patients transported was 25.1 (SD=13.1). Patients were transported to Vancouver General (n=92), Victoria General (n=69), Royal Columbian (n=141), and other hospitals (n=28).

Mean total response times were significantly reduced. Mean response time from injury to definitive care using the Autolaunch method was 128 minutes (SD=79 mins) versus 240 minutes using the traditional dispatch method (SD=157 mins, $p < 0.005$). A noteworthy time savings occurred in the activation time interval. The mean activation time using the traditional dispatch method was 112 minutes (SD=109 mins) versus 26 minutes using Autolaunch (SD=46 mins, $p < 0.005$) (Table 6).

Table 5

Traditional HEMS Dispatch vs. Autolaunch

Results Summary	Dispatch Method	
	Traditional HEMS	Autolaunch
Number of Requests	245	524
Number of Cancellations	15	194
Number of Completed flights	230	330
Mean Age (years)	40	46
Mean ISS	30	25
Mean TRISS	0.96	0.92

Table 6

Response Times to Major Trauma: Traditional HEMS Dispatch vs. Autolaunch

Total Response Time Elapsed time from injury to arrival at definitive care	**Dispatch Method**	**Mean**	**Median**	**Standard Deviation**	**P Value**	**Mean Time Savings Using Autolaunch**
	Traditional HEMS (n=230)	**240 mins**	**215 mins**	**157 mins**	**< 0.05**	112 mins
	Autolaunch (n=330)	**128 mins**	**110 mins**	**79 mins**	**< 0.05**	
Activation Time Elapsed time from injury to helicopter dispatch	**Traditional HEMS (n=230)**	**112 mins**	**87 mins**	**108 mins**	**< 0.05**	86 mins
	Autolaunch HEMS (n=330)	**26 mins**	**8 mins**	**46 mins**	**<0.05**	

4.8 Key Findings

Early activation of HEMS prior to the arrival of ground-EMS has significantly expedited treatment and transport of trauma patients in BC. The significant reduction in activation times is attributed to the involvement of 9-1-1 dispatchers communication with non-medical witnesses at the scene of accidents. The information extracted from these callers enables the dispatcher to efficiently determine the need for Autolaunch and then simultaneously send HEMS and ground-EMS directly to the scene. This study provides a starting point to begin an analysis of how expedited transport by HEMS is influencing health outcomes for victims of major trauma (Wheeler, et. al., 2009).

5: RECOMMENDATIONS

5.1 Addressing Data Gaps

1. The current literature does not speak to the long-term health outcomes and trauma patients treated and transported by HEMS (Belway et al., 2006; Biewener et al., 2004; Davis et al., 2005; Mc Murty et al., 1989). Steps should taken to create data linkages between BCAS, BCTR, the BC Coroners Service, and the National Ambulatory Care Reporting System to more precisely calculate short-term and long-term trauma related morbidity and mortality.
2. TRISS analyses will likely remain popular because prospective randomized trials of HEMS are impractical given logistic, economic, and ethical factors (Biewener et al., 2004; Davis et al., 2005). As trauma medicine advances, a further analyses of trauma metrics like the TRISS that inform our understanding of injury severity and survival need to be continually improved and periodically validated.
3. Current air-ambulance dispatch systems in BC do not sufficiently capture the motivating criteria for HEMS activation or cancellation. Cancellations can occur along the continuum of HEMS dispatch—from 911 caller to arrival of HEMS. Unfortunately the current dispatch system does not account for the cancellation reasons. So it remains unclear if the patient

died prior to arrival of HEMS, or conversely, suffered only minor injuries and required only ground ambulance transport. Furthermore, the current dispatch system fails to account for instances when the helicopter crew is busy on another call (ie. Intensive care unit inter-hospital transfer). Failure to account for these situations prevents analysts from deciphering true “missed” calls from under-triage or inefficient dispatch.

Recording the data that informs HEMS dispatch will allow researchers to analyze the sensitivity and specificity of each criterion, and in turn, improve the robustness of the dispatch criteria and overall efficiency of HEMS. The new dispatch system being implemented in 2010 will account for these discrepancies.

4. The interpretation of under-triage rates in the literature requires a more in-depth analysis. The concern is that under-triage rates may speak to inefficient dispatch criteria or that HEMS was simply too busy to respond. Again, the current dispatch system does not account for the reasons that HEMS were not activated. The importance of analyzing the dispatch criteria is vital because each under-triage situation is a missed chance to reduce morbidity and mortality in the pre-hospital setting (Ringburg et al., 2009). There could be a strong argument to expand HEMS capacity so that these “missed” opportunities for HEMS transport are eliminated.

5. Pre-hospital trauma data would be improved if dispatchers documented the reasons for HEMS cancellation. That would mean that patients who die prior to transport are captured in the BCAS Trauma Transport database. This is crucial in rural areas where response times are longer. Doing so would capture the most severely injured patients and highlight future populations that may benefit from HEMS. Until such time, it is recommended that the BCTR link with the BC Coroners Service data to capture pre-hospital trauma deaths and identify high-risk populations that could benefit from HEMS.
6. The financial justification of HEMS is hindered by a lack of evidence. Questions about the costs of Autolaunch in BC will be best appreciated once an analysis of long-term health outcomes is done. There are speculations that HEMS in BC is an overly expensive patient retrieval system, and conversely, that it is cost effective because of reduced length of stay in hospital. Without the aforementioned improved data linkages the cost-benefit analyses are unreliable at best (Taylor, Stevenson, Jan, Middleton & Myburgh, 2009).
7. Without sufficient evidence, the strategies and tactics used for HEMS deployment to adults cannot be generalized to pediatric populations. “Significant physiologic differences between adult and pediatric trauma victims preclude the direct application of adult strategies to pediatric populations” (Larson, 2004, p.89). Because of poor data linkages, the BC Autolaunch Study by Wheeler et. al. (2009) was unable to conduct a sub-

analysis of pediatric patients. It is recommended that a study be undertaken that includes this population group and its unique needs.

5.2 Improving Autolaunch Deployment

1. HEMS are only one part of the network that provides emergency health services. One way of improving the efficiency of HEMS is to strengthen the capacity of those providers who immediately liaise with HEMS on-scene (Hawkins et al., 2001). For example, scene times could be further reduced if definitive airway support and intravenous therapy was initiated by ground-EMS prior to the arrival of the aircraft. In the BC Autolaunch study only 56% of patients who required airway support were successfully intubated using an advanced airway management technique prior to the arrival of HEMS. Delay of these advanced procedures contributes to longer scene times and is an opportunity to reduce the overall time to definitive care. As the scope of practice of ground-EMS paramedics increases so too will their ability to seamlessly pass patients onto HEMS.
2. Improving the trauma system in BC depends on having Autolaunch expanded across the province—both helicopters and planes. “In a province as large as BC, it would take multiple HEMS bases to be effective” (L'Heureux, 2009). As a step forward it is recommended that pilot studies, like the one that guided HEMS Autolaunch in southwestern BC, be initiated throughout the interior and northern regions of the

province that have high rates of trauma mortality and significantly longer transport times. Early activation of HEMS and fixed-wing EMS in these areas has the potential to reduce response times and improve health outcomes (L'Heureux, 2004).

5.3 Future Directions

1. HEMS resources are scarce in BC. With increasing numbers of inter-hospital critical care transports the ability to respond to emergency scenes is reduced. Known and emerging hazards such as disease epidemics, environmental catastrophes, and rapid changes in population density could be used as "natural" experiments to test the surge capacity of HEMS. For example, the 2010 Olympics provides an opportunity to examine how changes in traffic congestion influence the need to use HEMS Autolaunch in non-traditional ways within city limits.
2. Enhancing mutual-aid agreements with neighboring HEMS agencies such as "STARS" air-ambulance in Alberta provide additional opportunities to enhance Autolaunch capabilities when the trauma system is overloaded.
3. Wheeler et al. (2009) examined a component of the pre-hospital system, but this is just one leg of the patient's journey from injury to recovery. A similar analysis could be done to evaluate the intra-hospital response to major trauma (ie. trauma-team activation, levels of intervention required, discharge-disposition, and prescribed follow-up). Doing so may

reveal ways to streamline the trauma system further and improve health outcomes.

4. A wider perspective of HEMS use that considers the built and natural environment is needed. Geographic information systems (GIS) should be utilized in BC to better understand and identify patterns of injury, trauma system access, trauma outcomes, and at-risk communities (Branas et al., 2005; Edelman, 2007). This type of GIS analysis was successfully used to model optimal locations for HEMS bases and receiving hospitals in BC's Interior Health region (Schuurman et al., 2009). If supported by the aforementioned data linkages these analyses will significantly advance the decision-making capability of dispatchers, HEMS personnel, and policy makers alike.

6: CONCLUSION

Trauma is often predictable and preventable. Despite primary prevention efforts trauma remains a significant, yet underrepresented, public health problem in BC, Canada, and worldwide. Responding to this, BCAS helicopter emergency medical services (HEMS) have established themselves as a vital link between emergency scenes and definitive care at British Columbia's trauma receiving hospitals.

Through improved access, expeditious transport, and superior preclinical therapy the literature clearly indicates that direct transfer by HEMS from an emergency scene to a level-1 trauma center significantly reduces mortality (Berlot et al., 2009; Biewener et al., 2004; Boyd et al., 1989; Cudnik et al., 2008; Mitchell et al., 2007; Sampalis et al., 1997; Thomas et al., 2000). The present study by Wheeler et. al. (2009) adds further evidence to the argument that the early activation of HEMS using information provided by 9-1-1 callers can significantly reduce response times to major trauma patients in British Columbia. Reducing response times in this way is improving trauma care by transporting patients directly to level-1 trauma centres where improved survival rates have been observed. The impacts on long-term health outcomes related to HEMS treatment and transport have not yet been substantiated, nor has the efficacy of fixed-wing Autolaunch.

To address these gaps the next steps are to improve linkages between data repositories and begin feasibility studies to bring early activation of HEMS to other high-risk areas of the province. These steps will contribute to our understanding of the broader health impacts from HEMS and hopefully cultivate the political will needed to expand Autolaunch across British Columbia.

7: APPENDIX A

Trauma Score

Measurement	Parameter	Score	Sub-total
Respiratory Rate	10-24	4	
	25-35	3	
	> 35	2	
	0-9	1	
Respiratory Effort	Normal	1	
	Shallow	0	
Systolic Blood Pressure	> 90	4	
	70-90	3	
	50-69	2	
	<50	1	
	No carotid pulse	0	
Capillary Refill	Normal	2	
	Delayed	1	
	Absent	0	
Glasgow Coma Score			
Eye opening	Spontaneous	4	
	To voice	3	
	To pain	2	
	None	1	
Verbal Response	Oriented	5	
	Confused	4	
	Inappropriate words	3	
	Incomprehensible words	2	
	None	1	
Motor Response	Obeys commands	6	
	Localizes	5	
	Withdraws	4	
	Abnormal flexion	3	
	Abnormal extension	2	
	None	1	
GCS Total			
Total GCS Points	14-15	5	
	11-13	4	
	8-10	3	
	5-7	2	
	3-4	1	
	Total Trauma Score		

8: APPENDIX B

The probability of survival for any one patient can be estimated from the following formula

$$Ps = 1/(1 + e^{-b})$$

Where $b = b_0 + b_1$ (Trauma score) + b_2 (Inury Severity Score) + b_3 (Age)
$B_{0...3}$ are coefficients derives from Walker-Duncan regression analysis applied to data from patients in the Major Trauma Outcome Study.

Values for weighted coefficients

	b_0 ***Constant***	***b_1*** ***Trauma Score***	***b_2*** ***Injury Severity Score***	***b_3*** ***Age***
Blunt Injury	*-1.6465*	*0.5175*	*-0.0739*	*-1.9261*
Penetrating Injury	*-0.8068*	*0.5442*	*-0.1159*	*-2.4782*

Example: A 40-year-old patient involved in blunt trauma
Trauma Score = 11
Injury Severity Score = 45

$$Ps = 1/(1 + e^{-b})$$
$$b = b_0 + b_1 + b_2 + b_3$$
$$b = (-1.6465) + (0.5175)(11) + (-0.0739)(45) + (-1.9261)(0)$$
$$b = -1.6465 + 5.6925 - 3.325 + 0$$
$$b = 0.7205$$
$$Ps = 1/(1 + 2.718281^{-(0.7205)})$$
$$Ps = 1/(1 + 0.4865)$$
$$Ps = 0.673$$

Therefore this patient's probability of survival is 0.673 or 67%

This TRISS example was originally cited by Boyd, Tolson & Copes (1987) p. 372

9: APPENDIX C

Data Collected by BC Trauma Registry

DEMOGRAPHIC

Facility (Calculated)
Site
Trauma Number (Calculated)
Entry Form (Calculated)
Medical Record Number
Personal Health Care Number
Accepting Facility Registration Date
Accepting Facility Registration Time
Patient Name - Last
Patient Name - First
Patient Name - Middle
Date of Birth
Age (Years) (Calculated)
Sex
Weight
Patient City
Patient City - If Other
Patient Province (Calculated if BC City)
Patient Province - If Other
Patient Country (Calculated for Provinces & States)
Patient Country - If Other
Postal Code
Other Postal Code
Readmission
Related Admission At Another Facility
Facility

INCIDENT

Incident Date
Incident Time
Place of Injury - Primary
Place of Injury - Specify
Incident Location Address
Incident Location City
Incident Location City - If Other
Incident Location Province (Calculated if BC City)
Incident Location Province - If Other
Incident Location Country (Calculated for Provinces & States)
Incident Location Country - If Other
Incident Location Postal Code
Cause of Injury (E-code) - Primary
Cause of Injury (E-code) - Secondary
Cause of Injury (E-code) - Tertiary
Cause of Injury (E-Code) - Specify
Sports / Recreational Activity
Sports / Recreation - Specify
Work Related

Alleged Motivation
Primary Injury Type
Mechanism of Injury
Other Blunt Description
Vehicular Crash Type
Injured Person
Injured Person's Vehicle
Injured Person's Vehicle - If Other
Other Vehicle Involved
Other Vehicle Involved - If Other
Protective Devices (1 to 10)
Extrication Required
Extrication Time (Mins)
Rollover
Major Vehicle Damage
High Speed
Multiple Casualties
Death of Other Occupant
Ejected / Separated From Vehicle
Distance Ejected (Metres)
Bicyclist / Pedestrian Thrown / Run Over
Impact Type
Collision Detail - Primary
Collision Detail – Secondary

SCENE

Transport Mode (Primary)
Response Number (Primary)
Qualified Personnel (Primary) (1 to 3)
Arrived At Scene Date & Time
Departed From Scene - Date & Time
Scene Time (Hours) (Calculated)
Autolaunch
Systolic Blood Pressure
Heart Rate
Intubated
Unassisted Respiratory Rate
Paralytic Agents in Effect
GCS - Eye Opening
GCS - Verbal Response
GCS - Motor Response
GCS - TOTAL (Calculated)
Revised Trauma Score - Scene (Calculated)
Pediatric Trauma Score - Size
Pediatric Trauma Score - Airway
Pediatric Trauma Score - SBP
Pediatric Trauma Score - CNS
Pediatric Trauma Score - Open Wound
Pediatric Trauma Score - Skeletal
Pediatric Trauma Score - TOTAL
Airway Management (1 to 4)
Drugs Administered (1 to 5)
Fluid Management

FIRST FACILITY

First Facility Name
First Facility Name If Other
City
City If Other

Region
Type
First Facility Registration Date & Time
First Facility Separation Date & Time
Initial Pre-Hosp Time
LOS (Hrs)
Systolic Blood Pressure
Heart Rate
Intubated
Unassisted Respiratory Rate
Paralytic Agents in Effect
GCS - Eye Opening
GCS - Verbal Response
GCS - Motor Response
GCS - TOTAL (Calculated)
Revised Trauma Score (Calculated)
ASCOT (Calculated)
Temperature
Pediatric Trauma Score - Size
Pediatric Trauma Score - Airway
Pediatric Trauma Score - SBP
Pediatric Trauma Score - CNS
Pediatric Trauma Score - Open Wound
Pediatric Trauma Score - Skeletal
Pediatric Trauma Score - TOTAL
Toxicology Screen Results (1 to 5)
Major Procedures in ED (1 to 20)
Airway Management (1 to 4)
Drugs Administered (1 to 5)
First 24 Hours: Fluid Management
First 24 Hours: Units of Blood Given
First 24 Hours: Units of Platelets Given
First 24 Hours: Units of Plasma Given
Total ICU Days
X-Ray Results: C-Spine
X-Ray Results: Chest
X-Ray Results: Thoracic
X-Ray Results: Lumbar
X-Ray Results: Pelvis
X-Ray Results: Extremity
CT(A) Results: CT Head
CT(A) Results: CT Face
CT(A) Results: CT C-Spine
CT(A) Results: CTA Neck
CT(A) Results: CTA Chest
CT(A) Results: CT Abdomen
CT(A) Results: CTA T/L Spine
CT(A) Results: CT Pelvis
CT(A) Results: CTA Extremity
Date of OR (1 to 20)
Procedure (1 to 20)
Transport Mode From First Facility (Primary)
Response Number From First Facility (Primary)
Qualified Personnel From First Facility (Primary) (1 to 3)
Autolaunch

SECOND FACILTY

Second Facility Name
Second Facility Name If Other
City

City If Other
Region
Type
Second Facility Registration Date & Time
Second Facility Separation Date & Time
Initial Pre-Hosp Time
LOS (Hrs)
Systolic Blood Pressure
Heart Rate
Intubated
Unassisted Respiratory Rate
Paralytic Agents in Effect
GCS - Eye Opening
GCS - Verbal Response
GCS - Motor Response
GCS - TOTAL (Calculated)
Revised Trauma Score (Calculated)
ASCOT (Calculated)
Temperature
Pediatric Trauma Score - Size
Pediatric Trauma Score - Airway
Pediatric Trauma Score - SBP
Pediatric Trauma Score - CNS
Pediatric Trauma Score - Open Wound
Pediatric Trauma Score - Skeletal
Pediatric Trauma Score - TOTAL
Toxicology Screen Results (1 to 5)
Major Procedures in ED (1 to 20)
Airway Management (1 to 4)
Drugs Administered (1 to 5)
First 24 Hours: Fluid Management
First 24 Hours: Units of Blood Given
First 24 Hours: Units of Platelets Given
First 24 Hours: Units of Plasma Given
Total ICU Days
X-Ray Results: C-Spine
X-Ray Results: Chest
X-Ray Results: Thoracic
X-Ray Results: Lumbar
X-Ray Results: Pelvis
X-Ray Results: Extremity
FAST
CT(A) Results: CT Head
CT(A) Results: CT Face
CT(A) Results: CT C-Spine
CT(A) Results: CTA Neck
CT(A) Results: CTA Chest
CT(A) Results: CT Abdomen
CT(A) Results: CTA T/L Spine
CT(A) Results: CT Pelvis
CT(A) Results: CTA Extremity
Date of OR (1 to 20)
Procedure (1 to 20)
Transport Mode From Second Facility (Primary)
Response Number From Second Facility (Primary)
Qualified Personnel From Second Facility (Primary) (1 to 3)
Autolaunch

ACCEPTING FACILITY

Accepting Facility Registration Date & Time

Time to Accepting Facility Care (Hours) (Calculated)
Direct Admission
Systolic Blood Pressure
Heart Rate
Intubated (when GCS taken)
Unassisted Respiratory Rate
Paralytic Agents in Effect
Sedation in Effect
Temperature
GCS - Eye Opening
GCS - Verbal Response
GCS - Motor Response
GCS - TOTAL (Calculated)
Revised Trauma Score (Calculated)
ASCOT (Calculated)
Pediatric Trauma Score - Size
Pediatric Trauma Score - Airway
Pediatric Trauma Score - SBP
Pediatric Trauma Score - CNS
Pediatric Trauma Score - Open Wound
Pediatric Trauma Score - Skeletal
Pediatric Trauma Score - TOTAL
Toxicology Screen Results (1 to 5)
BAC (mmol/L)
Time First ABGs Taken at Accepting Facility
Time to First ABGs (Calculated) (Minutes)
First ABGs: pH
First ABGs: pO2
First ABGs: pCO2
First ABGs: HCO3
First ABGs: Base Excess
First Hemoglobin
Emergency Resources (1 to 2)
TS Consult: Called Date & Time
TS Consult: Arrived Date & Time
TS Consult: Lapse Time (Mins)
TS Consult: Response Time (Mins)
Trauma Team: Activated Date & Time
Trauma Team: Arrived Date & Time
Trauma Team: Lapse Time (Mins)
Trauma Team: Response Time (Mins)
ED Consulting Service (1 to 6)
Called Date & Time (1 to 3)
Arrived Date & Time (1 to 3)
Lapse Time (Mins) (Calculated) (1 to 3)
Response Time (Mins) (Calculated) (1 to 3)
Major Procedures in ED (1 to 20)
Airway Management (1 to 4)
Drugs Administered (1 to 5)
First 24 Hours: Fluid Management
First 24 Hours: Units of Blood Given
First 24 Hours: Units of Platelets Given
First 24 Hours: Units of Plasma Given
X-Ray Results: C-Spine
X-Ray Results: Chest
X-Ray Results: Thoracic
X-Ray Results: Lumbar
X-Ray Results: Pelvis
X-Ray Results: Extremity
CT(A) Results: CT Head
CT(A) Results: CT Face
CT(A) Results: CT C-Spine

CT(A) Results: CTA Neck
CT(A) Results: CTA Chest
CT(A) Results: CT Abdomen
CT(A) Results: CTA T/L Spine
CT(A) Results: CT Pelvis
CT(A) Results: CTA Extremity
Emergency Department Disposition Date & Time
Emergency Department Length of Stay (Hours) (Calculated)
Emergency Department Disposition
Emergency Department Disposition Detail
Admitting Physician Service
Most Responsible Physician Service
Total ICU Days
Total Days Ventilated
Total Special Care Unit Days

OR VISIT

Number of OR Visits
Date of OR
Start Time
Procedure (1 to 10)
Service (1 to 10)

DIAGNOSES

AIS Revision (Calculated)
Injury Description (1 to 27)
AIS Code & Severity (1 to 27) (Calculated)
Max. AIS by ISS Body Region - Head / Neck (Calculated)
Max. AIS by ISS Body Region - Face (Calculated)
Max. AIS by ISS Body Region - Chest (Calculated)
Max. AIS by ISS Body Region - Abdomen / Pelvic Contents (Calculated)
Max. AIS by ISS Body Region - Extremities / Pelvic Girdle (Calculated)
Max. AIS by ISS Body Region - External (Calculated)
Injury Severity Score (Calculated)
TRISS (Calculated)
Additional Diagnoses
Additional Anatomical Diagnoses

CO-MORB/COMPLICATIONS

Co-morbidity (1 to 9)
Co-morbid Factor (1 to 10)
Complication (1 to 10)
ICD-10-CA (1 to 10)
AIS Code (1 to 10)
Reviewed (1 to 10)
Nature (1 to 10)
Phase of Care (1 to 10)
Provider Related Detail (1 to 10)
System Related Detail (1 to 10)
Care (1 to 10)
Impact (1 to 10)
Death (1 to 10)
Corrective Action (1 to 10)
Corrective Action - If Other (1 to 10)
Status (1 to 10)
Missed Organ Donation (for Complication of Death)
Alcohol Screening BAC
AUDIT/CAGE

Intervention
Intervention If Other

OUTCOME

Separation Date & Time
Length of Stay (Days) (Calculated)
Expired
Resuscitation Attempted
Expired Location
Expired Location Detail
Autopsy Type
Autopsy Report Reviewed
Extent of Autopsy
Organs Donated
Tissue Donated
Separation Disposition
Facility Transferred To
Facility Transferred To - If Other
Transport Mode

10: REFERENCES

Báez, A. A., Lane, P. L., Sorondo, B., & Giraldez, E. M. (2006). Predictive effect of out-of-hospital time in outcomes of severely injured young adult and elderly patients. *Prehospital and Disaster Medicine, 21*(6), 427.

BCAS (2008). *British columbia ambulance service statistics*. [Pamphlet] Retrieved September 1, 2009, from http://www.bcas.ca/EN/main/about/statistics.html

Belway, D., Henderson, W., Keenan, S. P., Levy, A. R., & Dodek, P. M. (2006). Do specialist transport personnel improve hospital outcome in critically ill patients transferred to higher centers? A systematic review. *Journal of Critical Care, 21*(1), 8-17.

Berlot, G., Fata, C. L., Bacer, B., Biancardi, B., Viviani, M., Lucangelo, U., et al. (2009). Influence of prehospital treatment on the outcome of patients with severe blunt traumatic brain injury: A single-centre study. *European Journal of Emergency Medicine, 0*(0), 1-6.

Berns, K. S., Caniglia, J. J., Hankins, D. G., & Zietlow, S. P. (2003). Use of the autolaunch method of dispatching a helicopter. *Air Medical Journal, 22*(3), 35.

Biewener, A., Aschenbrenner, U., Rammelt, S., Grass, R., & Zwipp, H. (2004). Impact of helicopter transport and hospital level on mortality of polytrauma patients. *The Journal of Trauma: Injury, Infection, and Critical Care, 56*(1), 94.

Bledsoe, B., & Smith, M. (2004). Medical helicopter accidents in the United States: A 10-year Review. *J Trauma, 56*, 1325-1329.

Boyd, C. B., Corse, K. C., & Cambell, R. C. (1989). Emergency interhospital transport of the major trauma patient: Air versus ground. *The Journal of Trauma, 29*(6), 789-794.

Boyd, C. R., Tolson, M. A., & Copes, W. S. (1987). Evaluating trauma care: The TRISS method. *The Journal of Trauma: Injury, Infection, and Critical Care, 27*(4), 370.

Branas, C. C., MacKenzie, E. J., Williams, J. C., Schwab, C. W., Teter, H. M., Flanigan, M. C., et al. (2005). Access to trauma centers in the United States. *JAMA*, 293(21), 2626-2633.

Brooks, A., Burton, T., Williams, J., & Mahoney, P. (2001). Trauma teams. *Trauma*, *3*(4), 211.

CAEP (2009). Research in emergency medicine . [Web page] Canadian Association of Emergency Physicians . (Original work published 2009) Retrieved October 1, 2009, from http://www.caep.ca

Campbell, B. T., Saleheen, H., Borrup, K., McQuay, J., Luk, S., Hiscoe, J., et al. (2009). Epidemiology of trauma at a level 1 trauma center. *Connecticut Medicine*, *73*(7), 389.

CDC (2009, January 23). Morbidity and mortality weekly report . *Guidelines for field triage of injured patients: Recommendations of the national expert review panel on field triage*. Centers for Disease Control and Prevention. Retrieved June 8, 2009, from www.cdc.gov/mmwr

CIHI (2007, May 9). *National trauma registry 2006 injury hospitalizations highlights report*. Canadian Institute for Health Information. Retrieved June 8, 2009, from http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page =reports_ntr_bulletins_e

Cady, G. (1999). The Medical Priority Dispatch System—A System and Product Overview. Retrieved from http://www.emergencydispatch.org/articles/ArticleMPDS%28Cady%29.html

Cox, H. L., Laupland, K. B., & Manns, B. J. (2006). Economic evaluation in critical care medicine. *Journal of Critical Care*, *21*(2), 117-124.

Cudnik, M. T., Newgard, C. D., Wang, H., Bangs, C., & Herrington IV, R. (2008). Distance impacts mortality in trauma patients with an intubation attempt. *Prehospital Emergency Care*, *12*(4), 459-466.

Danne, P. D. (2003). Trauma management in Australia and the tyranny of distance. *World J Surg*, *27*(4), 385-389.

Davis, D. P., Peay, J., Serrano, J. A., Buono, C., Vilke, G. M., Sise, M. J. (2005). The impact of aeromedical response to patients with moderate to severe traumatic brain injury. *Annals of Emergency Medicine*, *46*(2), 115-122.

Diaz, M. A., Hendey, G. W., & Bivins, H. G. (2005). When is the helicopter faster? A comparison of helicopter and ground ambulance transport times. *The Journal of Trauma: Injury, Infection, and Critical Care*, *58*(1), 148.

Edelman, L. S. (2007). Using geographic information systems in injury research. *Journal of Nursing Scholarship*, *39*(4), 306-311.

Evans, D. C. (2007). From trauma care to injury control: A people's history of the evolution of trauma systems in Canada. *Canadian Journal of Surgery*, *50*(5), 364.

Falcone, R. E., Herron, H., Werman, H., & Bonta, M. (1998). Air medical transport of the injured patient: Scene versus referring hospital. *Air Medical Journal*, *17*(4), 161.

FARE (2006). *Air medicine: Accessing the future of health care*. Foundation for Air-medical Research and Education. Retrieved October 12, 2009, from www.fareonline.org

Frankema, S. P. G., Ringburg, A. N., Steyerberg, E. W., Edwards, M. J. R., Schipper, I. B., & van Vugt, A. B. (2004). Beneficial effect of helicopter emergency medical services on survival of severely injured patients. *British Journal of Surgery*, *91*, 1520-1526.

Gaston, S. G. (1971). Accidental death and disability: The neglected disease of modern society. *The Journal of Trauma*, *11*(3), 195-206.

Girolami, G. A., & Little, R. L. (1999). Changes in the causes of trauma in the last 20 years . *Trauma*, *1*(3), 3-11.

Gwinnutt, C., Bethelmy, L., & Nolan, J. (2003). Anaesthesia in trauma. *Trauma*, *5*(1), 51.

Hall, J. C., Dobb, G., & Hall, J. L. (2001). An evaluation of outcome after severe trauma. *Journal of Quality in Clinical Practice*, *21*(3), 66-68.

Hamilton, N. E. (2002). Regionalization of trauma care: British Columbia, Canada. *The Journal of Trauma: Injury, Infection, and Critical Care*, *52*(1), 6.

Hankins, D. G. (2006). Air medical transport of trauma patients. *Prehospital Emergency Care*, *10*(3), 324-327.

Hawkins, S. C., Morgan, S., Waller, A., Winslow, T., & McCoy, M. (2001). Effects of ground EMS and ED personnel on air medical trauma on-site times. *Air Medical Journal*, *20*(3), 32.

Higgins, R. B., & Kerstein, M. D. (1995). Study of multiple rotor-wing flight programs on emergency medical services. *Air Medical Journal*, *14*(4), 206.

IOM (2007). *Emergency medical services at the crossroads: Committee on the future of emergency care in the united states health system*. Washington, DC: Institute of Medicine of the National Academies.

Judge, T. (2007). HEMS: Luxury or necessity?. *Air Medical Journal*, *26*(6), 256-258.

Kleinman, M. E. (2009). Regionalization of critical care: Not just for kids*. *Crit Care Med*, *37*(7), 2303.

L'Heureux , R. L. (2004). *Autolaunch trial: Summary report July 1, 2004 – October 1, 2004*. Victoria, BC: British Columbia Ambulance Service.

L'Heureux, R. (2009, September 9). BCAS manager of critical care air-transport programs. [email correspondence].

Larson, J. T., Dietrich, A. M., Abdessalam, S. F., & Werman, H. A. (2004). Effective use of the air ambulance for pediatric trauma. *The Journal of Trauma: Injury, Infection, and Critical Care*, *56*(1), 89.

Leppaniemi, A. K. (2009). Update on global trends in trauma. *Trauma*, *11*(1), 37.

Mauritz, W., Nerlich, M., UK, J. N., UK, P. O., Parr, M., Seekamp, A. (2000). Recommendations for uniform reporting of data following major trauma-the utstein style. *Trauma*, *2*, 43-61.

McMurty, R. Y., Nelson, W. R., & de la Roche, M. R. (1989). Current concepts in trauma. *Canadian Medical Association Journal*, *141*, 529.

McDonald, A. C. (2006). Critical care transport teams: Searching for evidence of effectiveness. *Journal of Critical Care*, *21*(1), 17-18.

Mitchell, A. M., Tallon, J. T., & Sealy, B. S. (2007). Air versus ground transport of major trauma patients to a tertiary trauma centre: A province-wide comparison using TRISS analysis. *Canadian Journal of Surgery*, *50*(2), 129-133.

Mock, C., Arafat, R., Chadbunchachai, W., Joshipura, M., & Goosen, J. (2008). What world health assembly resolution 60.22 means to those who care for the injured. *World Journal of Surgery*, *32*(8), 1636-1642.

Mogo, C. M., & Harstall, C. H. (2008, February). *Air ambulance with advanced life support*. Institue of Health Economics. Alberta.

Moore, L., Lavoie, A., Turgeon, A. F., Abdous, B., Sage, N. L., Marcel, M. E. (2009). The trauma risk adjustment model A new model for evaluating trauma care . *Annals of Surgery*, *249*(6). Retrieved May, 2009, from www.annalsofsurgery.com

Murray, S. (2006). Public health: Global injury and violence. *CMAJ: Canadian Medical Association Journal*, *174*(5), 620.

Nicholl, J. P., Brazier, J. E., & Snooks, H. A. (1995). Effects of London helicopter emergency medical service on survival after trauma. *British Medical Journal*, *311*(6999), 217-222.

NRC (1966). *Accidental death and disability: The neglected disease of modern society.* National Research Council . Retrieved October 1, 2009, from http://www.nap.edu/

NTR (2006). National Trauma Registry 2006 Report: Major Injury in Canada. Canadian Institue for Health Information. Retrieved August, 2009, from http://www.icis.ca/cihiweb/dispPage.jsp?cw_page=reports_e

Petrie, D. A., Tallon, J. M., Crowell, W., Cain, E., Martell, P., & McManus, D. (2007). Medically appropriate use of helicopter EMS: The mission acceptance/triage process. *Air Medical Journal*, *26*(1), 50-54.

PHWG (1999, May 21). *National injury prevention and control strategy*. Public Health Working Group. Retrieved June 1, 2009, from www.injuryresearch .bc.ca

Powell, D. G., Hutton, K., King, J. K., Mark, L., McLellan, H. M., McNab, J. (1997). The impact of a helicopter emergency medical services program on potential morbidity and mortality. *Air Medical Journal*, *16*(2), 48.

Purtill, M. A., Benedict, K., Hernandez-Boussard, T., Brundage, S. I., Kritayakirana, K., Sherck, J. P. (2008). Validation of a prehospital trauma triage tool: A 10-year perspective. *The Journal of Trauma: Injury, Infection, and Critical Care*, *65*(6), 1253.

Rajabali, F., Han, G., Artes, S., Smith, D., Brussoni, M., & Joshi, P. (2005, January). *Unintentional injuries in british columbia: Trends and patters among children and youth*. BC Injury Research and Prevention Unit. Retrieved June 1, 2009, from www.injuryresearch.bc.ca

Ringburg, A. N., Gijs de Ronde, M. D., Thomas, S. H., van Lieshout, E. M. M., Patka, P., & Schipper, I. B. (2009). Validity of helicopter emergency medical services dispatch criteria for traumatic injuries: A systematic review. *Prehospital Emergency Care*, *13*(1), 28-36.

Ringburg, A. N., Spanjersberg, W. R., Frankema, S. P. G., Steyerberg, E. W., Patka, P., & Schipper, I. B. (2007). Helicopter emergency medical services (HEMS): Impact on on-scene times. *The Journal of Trauma: Injury, Infection, and Critical Care*, *63*(2), 258.

Rodenberg, H. (1996). Scoring systems in air medical transport: A primer. *Air Medical Journal*, *15*(4), 184.

Sahai, V. S., Ward, M. S., Zmijowskyj, T., & Rowe, B. H. (2005). Quantifying the iceberg effect for injury: Using comprehensive community health data [published erratum appears in can J public health 2006; 97 (1): 34]. *Can J Public Health*, *96*(5), 328-32.

Sampalis, J. S., Denis, R., Frechette, P., Brown, R., Fleiszer, D., & Mulder, D. (1997). Direct transport to tertiary trauma centers versus transfer from lower level facilities: Impact on mortality and morbidity among patients with major trauma. *The Journal of Trauma*, *43*(2), 288.

Schuurman, N., Bell, N. J., L'Heureux, R., & Hameed, S. M. (2009). Modelling optimal location for pre-hospital helicopter emergency medical services. *BMC Emergency Medicine*, *9*(1), 6.

Schuurman, N., Hameed, S. M., Fiedler, R., Bell, N., & Simons, R. K. (2008). The spatial epidemiology of trauma: The potential of geographic information science to organize data and reveal patterns of injury and services. *Canadian Journal of Surgery*, *51*(5), 389.

Shatney, C. H., Homan, S. J., Sherck, J. P., & Ho, C. C. (2002). The utility of helicopter transport of trauma patients from the injury scene in an urban trauma system. *The Journal of Trauma: Injury, Infection, and Critical Care*, *53*(5), 817.

Shepherd, M. V., Trethewy, C. E., Kennedy, J., & Davis, L. (2008). Helicopter use in rural trauma. *Emergency Medicine Australasia*, *20*(6), 494-499.

Tay, S. Y., Sloan, E. P., Zun, L., & Zaret, P. (2004). Comparison of the new injury severity score and the injury severity score. *The Journal of Trauma: Injury, Infection, and Critical Care*, *56*(1), 162.

Taylor, C. B., Stevenson, M., Jan, S., Middleton, P. M., & Myburgh, J. (2009). The cost effectiveness of helicopters for out-of-hospital transport. *Injury Extra*, *40*(8), 146-146.

Thomas, S. H. (2007). Helicopter EMS transport outcomes literature: Annotated review of articles published 2004-2006. *Prehospital Emergency Care*, *11*(4), 477-488.

Thomas, S. H., Wedel, S. K., Buras, W., & Harrison, T. H. (2000). Association between helicopter transport and blunt trauma survival. *Academic Emergency Medicine*, *7*(5), 511.

VCH (2007). *Regional trauma program annual report 2006-2007*. Vancouver Coastal Health. Retrieved June 1, 2009, from http://www.bcchildrens .ca/info

Wheeler, S., L'Heureux, R., Danielson, K., Lhaka, N., Simons, R. (2009). British Columbia HEMS Autolaunch Study. Unpublished manuscript.

WHO (2008). The global burden of disease: 2004 update. Retrieved June 1, 2009 from http://www.who.int/healthinfo/global_burden_disease/en/

Wish, J. R., & Davis, D. P. (2005). Auto launch/early activation: A survey of AAMS members and literature review. *Air Medical Journal*, *24*(2), 83-88.