Evaluation of Pre-Hospital Trauma Services in Montreal

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Abstract

The objectives of this observational study were to describe and evaluate the impact of emergency services on trauma mortality in Montreal. Urgences-Santé provides pre-hospital care in the greater Montréal region. Physicians provide on-scene care including advanced life support (ALS). Basic life support (BLS) is provided by emergency medical technicians or physicians. The study was conducted over a one-year period from April 1, 1987 to March 31, 1988.

The results of this study showed that the response and total pre-hospital times of Urgences-Santé were similar to those in other North American cities. Pre-hospital time exceeding 60 minutes was associated with increased mortality. A significant trend towards lesser mortality in hospitals with higher level trauma care was observed. The use of ALS by physicians was not associated with reduced mortality. However, ALS and the presence of a physician were significantly associated with increased pre-hospital time.

Résumé

Les objectifs de cette étude d'observation sont de décrire et évaluer l'impact des services d'urgence sur la mortalité due aux traumatismes a Montreal. Urgences sante prodigue les soins préhospitaliers dans la region métropolitaine de Montréal. Sur les lieux, des médecins administrent des soins pouvant inclure les soins avancés (ALS,"Advanced life support"). Les soins de base ("Basic life support") sont prodigués par les techniciens ambulanciers ou par les médecins. Cette etude s'est deroulee sur une période d'un an, soit du 1er avril 1987 au 31 mars 1988.

Les résultats de l'étude démontrent que les délais d'intervention et les délais préhospitaliers totaux d'Urgences santé sont comparables à ceux des autres villes nord-américaines. Un délais préhospitalier superieur a 60 minutes est associé à une mortalité plus élevee. On observe une tendance significative à une réduction de la mortalite pour les hopitaux capables d'un niveau d'intervention plus poussé. L'accomplissement par les médecins des soins avancés n'est pas associé à une mortalite reduite. Par contre, les soins avancés et la présence d'un médecin sur les lieux sont significativement associés à de plus longs délais préhospitaliers.

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Statement of Originality

This study was one of two projects evaluating pre-hospital services provided by Urgences-Santé in the Montreal region. I was involved in the initial conception of the study and participated in the decisions regarding its development. I designed and developed the software used to collect and manage the data for both studies. The formulation of the study objectives, the decisions regarding the specific methods and the statistical analyses were solely my responsibility. This study contributes original knowledge in the area of trauma care in that it focuses on pre-hospital care in a large North American city provided by physicians who are part of the emergency medical system.

No comparable study evaluating or describing this or another similar system using methods applied by the current study has been reported.

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CHAPTER 1. STATEMENT OF THE PROBLEM AND RATIONALE

INTRODUCTION

The purpose of the first chapter is to provide the background and rationale for the present study. Following a brief introduction on the theory of trauma causation, the impact of trauma in the USA, Canada, Quebec, and Montreal is outlined. Several issues related to interventions against injuries, the outcome of trauma, and factors influencing trauma outcome, are summarized. Methodological issues regarding the evaluation of pre-hospital trauma services are also presented.

A brief section on injury severity measures is presented in this chapter because references to these measures are made throughout the subsequent chapters. An evaluation of these measures is beyond the scope of this thesis; therefore these instruments are described without in-depth critique or performance comparison.

A description of the components of emergency medical services as well as their development in the USA and Montreal is also outlined. Finally, the rationale and objectives of the present study are presented.

Several sections of the first chapter summarize points from the literature in the area of trauma care. These points are presented in more detail in the second chapter. Although there is considerable overlap between the first and

second chapters, it was necessary to include these issues in the first chapter in order to define terms of reference and to establish the rationale for the current study.

1.1. INJURY AS ILLNESS

Trauma or injury is generally defined as the damage resulting from exposure to physical energy at rates which exceed the level of the body's resilience (Robertson, 1983:1-2). Trauma has been used as the medical term describing injury. There are three factors involved in the occurrence of an injury: the host, the agent, and the environment. The host is the organism which sustains the injury or damage, the agent is the vector or carrier of the physical energy which produces the damage, and the environment constitutes the physical surroundings where the interaction between the host and the agent takes place (Benner,1975; Waller,1984:1-38).

A key concept in the injury causation model is the continuous interaction between the host and physical energy in the environment. The individual's ability to maintain equilibrium with the environmental energy is a basic variable in the equation determining the probability of an injury event. When the requirements of maintaining equilibrium with the environmental energy exceed the capabilities of the individual, the probability of an injury event increases. The disturbance in equilibrium may result from a deterioration of the individual's capabilities, an overwhelming increase in the existing energy, or both. At this point in time an injury or damage to the host has not yet occurred. The time period which precedes the actual

release of the environmental energy is the pre-injury phase (Waller,1984:13-32).

The time period during which the energy is released from the environment and is transferred to the host is the injury phase. Haddon pointed out that the damaging agent is generally environmental physical energy which is transformed to kinetic energy and is subsequently transferred to the host (Haddon,1963). Damage to the body results from the transfer of energy in sufficient amounts to destroy the integrity of tissues. Waller further specified that in order for most injuries to occur, the transfer of the kinetic energy must occur over a short period of time, in fact, fractions of seconds. The severity of the damage to the body depends on three factors: first, the rate of energy transfer which is defined as the amount of energy per unit time per unit of body tissue area, second, the nature of the agent transferring the energy, and third, the physical characteristics of the tissue involved (Waller,1984;13-32).

The post-injury phase follows the injury phase. The ultimate outcome of the injury depends substantially on the course of events which take place during this phase. At this point in time, the prompt and adequate repair of the bodily damage play a significant role in reducing the seriousness of the consequences of the injury. It is in this context and during this phase that emergency medical care becomes relevant and important.

1.2. TRAUMA AS A HEALTH PROBLEM

1.2.1. United States

During the last decade, in the United States, injuries have been reported as the major cause of death for individuals less than 45 years of age, and as the fourth leading cause of death for all ages combined (Baker et al.,1984:8-15; Robertson,1983:2-8; Waller,1984:93-105). In 1983, an estimated 140,000 deaths in the U.S. were caused by injuries (Committee on Trauma Research,1985:1-24). In 1986 this figure was approximately 180,000 (Health US,1988). Almost one half of the total deaths in children between the ages of 1 and 4 years, and approximately 80% of the deaths in individuals between 15 and 24 years of age are caused by injuries (Committee on Trauma Research,1985:1-24; Waller,1984:93-105).

Another measure of the impact of an illness is the potential years of life lost (PYLL). Assuming an overall average life span of 70 years, a death occurring at 65 years would contribute 5 PYLL. A death occurring at 70 years would contribute 0 PYLL and a death occurring at 25 years would contribute 45 PYLL. Given that the highest proportion of trauma deaths occur in children and in young adults, the burden of injuries on society becomes even more alarming when we consider the PYLL. In the United States, the reported annual total number of years of life lost due to injuries between 1980 and 1986 ranged from 4 million

(Committee on Trauma Research,1985;1-24) to over 5 million (Health US,1988). This constitutes almost 40% of the total years of life lost due to all illnesses, making injuries the major cause of PYLL (Committee on Trauma Research 1985:1-24).

The direct and indirect costs of trauma to U.S. society were estimated at $75-100 billion dollars in 1984 (Committee on Trauma Research,1985:1-25). In 1982, direct costs for 1982 for the care of trauma victims were estimated at 19 billion dollars, and costs incurred indirectly through the loss of earnings were estimated at 41 billion (Munoz,1984). In 1983, the average direct cost was estimated at approximately $5,000 per person for non-survivors and over $50,000 per person for survivors (Fischer et al.,1985). In 1980, injuries were the leading cause of physician-patient contacts in the U.S. amounting to 99 million such contacts. In addition, during the last decade injury victims occupied almost one eighth of all hospital beds in the U.S. and constituted 25% of all emergency room patients (Committee on Trauma Research,1985:1-24).

1.2.2. Canada

Injuries are as significant in Canada as they are in the Unites States. Between 1981 and 1986, injuries were the most common cause of death for individuals under 45 years of age. Overall, injuries were the fourth most common cause of death following cardiovascular disease, cancers and respiratory disease (Health Reports,1989). When age-adjusted rates are considered, injuries were the third leading cause of death in Canada for the 1985-86 period. Approximately 14,000 Canadians died because of accidents in 1986, resulting in an estimated annual rate of 48.9 per 100,000 population, and constituting 7.2% of all deaths (Mortality,1987; Health Reports,1989).

In 1986, accidental injuries (excluding suicides and violent crimes) were the third leading cause of potential years of life lost in Canadians. Of 1.5 million potential years lost, 304,000 years (18%) were due to accidents. When suicides and violent deaths are included, injuries were the leading cause of potential life years lost, accounting for 40% of all years lost (Mortality,1987; Health Reports,1989).

In 1985, injuries and poisoning were the fifth leading cause of separations in Canadian hospitals, comprising approximately 8% of total hospitalizations (Mortality,1986; 1987; Health Reports,1989).

1.2.3. Quebec

As in the U.S. and in Canada as a whole, injuries are a major health problem in Quebec. In 1980, trauma was the leading cause of death in Quebec residents younger than 45 years of age and the third leading cause of death for the whole population (Levasseur,1983). Data from 1987 show that the situation remains the same (Mortality,1988). In that year, trauma resulted in 3945 deaths, or 8% of all deaths in Quebec (Camirand et al.,1989), for an annual mortality rate of 59.1 per 100,000 population. For those younger than 45 years, trauma was the major cause of death, and in those between the ages of 15 and 24, it caused 80% of all deaths. During the same year, more than 50% of all deaths in Quebec in the 5-14 and 25-34 year age groups, and approximately one third of deaths in individuals between 1-4 and 35-44 years old were caused by injuries (Mortality,1988; Camirand et al.,1989).

In 1987, injuries were the primary cause of potential years of life lost for Quebec residents, resulting in the loss of a total of 112,000 years. This represents 40% of the total years lost due to all diseases. As with Canada as a whole, trauma was the fifth major reason for hospitalizations in Quebec. It is responsible for 8% of total hospital separations.

1.2.4. Montreal

In 1986, approximately 1600 Montreal residents were killed by trauma, making this the third leading cause of death in this region. As in Quebec as a whole, trauma was the major cause of death for individuals younger than 45 years of age, resulting in 849 deaths in this age group. The proportions of the total deaths caused by trauma in various age categories are similar for Montreal and Quebec. It must be noted that these figures represent the mortality statistics for residents in these areas regardless of the location of the accident.

Previous studies have commented on the impact of motor vehicle accident related injuries in the Montreal region. Bourbeau noted that in 1982, the rates of motor vehicle accident related injuries and mortality in Montreal were 50.9 and 7.9 per 100,000 population respectively. These rates were slightly lower than those observed for Quebec as a whole, where the motor vehicle accident associated severe injury and mortality rates were 71.2 and 9.2 per 100,000 population respectively. Bourbeau further observed that although the severe injury rate increased to 63.2 per 100,000 population in 1983 and 1984, the mortality rate for the region of Montreal remained constant for those years (Bourbeau,1983). One explanation for this may be that severely injured patients had a higher probability of survival in 1983 and 1984 because of improved care. An

alternative explanation could be that the injuries occurring in 1983-84 were less severe, thus leading to a higher survival rate. Detailed information on the injury characteristics, injury severity, and emergency trauma care provided would be necessary to provide a definitive explanation.

In 1983, Liddell reported a study on a cohort of approximately 18,000 Montreal drivers which who were followed from 1973 to 1976 inclusive. Of 4209 accidents observed, 14% resulted in injury and 0.4% resulted in death (Liddell,1983). In another study, Stulgivskas, Pless and Frappier identified 1767 children under 15 years of age who were injured in motor vehicle accidents in Montreal. Of these children, 83% were treated in emergency rooms, 9% were admitted to hospital and 0.9% died. These researchers observed that the highest rates of hospital admissions occurred for children injured as pedestrians (24%), and as cyclists (15%). Eight percent (8%) of children who were injured while passengers in motor vehicle, were admitted into a hospital (Stulgivskas et al.,1983).

Finally, data from a more recent report published by the Régie de l'assurance automobile du Quebec (RAAQ) show that for the three-month period of July-September 1987, a total of 405 motor vehicle accidents resulting in severe injury occurred in the greater Montreal region. Of these, 42(10%) were fatal (Bisson,1988).

1.3. INJURY CONTROL

1.3.1. The Outcomes of Trauma

The two major outcomes of severe injury are disability and death. The rate of severe disability from trauma is twice that of the mortality rate (Trunkey et al.,1983;1984; Bull,1975; Baker,1986). Research has focused primarily on the prevention of death. The rationale for this has been that measures which reduce mortality will also result in reduced disability.

Trunkey (1983) has classified trauma-related deaths into three categories, immediate, early and late depending on the time interval between the injury and death. Immediate deaths occur within two hours of the injury. Early deaths occur between two hours and seven days from the trauma. Late deaths occurr after the first week of the injury.

The majority of immediate deaths are not preventable and the prevention of late deaths depends on long-term in-hospital rather than pre-hospital care (Trunkey,1983). The impact of pre-hospital trauma services should be strongest in reducing early deaths (Trunkey,1983). Baker has estimated that almost 50% of all trauma-related deaths are immediate, that approximately 35% are early deaths, and that the remaining 15% are late deaths (Baker et al.,1980). Among the early deaths, Baker showed that 20% occur within several hours, 65% occur within two days and 15% occur between two and six days following the trauma (Baker et al.,1980).

1.3.2. Non-treatment Factors Affecting Trauma Outcome

Several researchers have identified non-treatment factors which influence the outcome of trauma. These factors include patient characteristics such as age, gender, and comorbidity; injury characteristics such as severity and mechanism of injury; and body region injured. These factors will be briefly described in the next section.

1.3.2.1. Severity

By far the most important predictor of the outcome of trauma is the severity of the injury. It is therefore necessary for clinical and research reasons to implement a system of describing injury severity. The early versions of the International Classification of Disease focused on classifying the cause of the injury and the body region injured rather on describing the nature of the injury or the severity. Specifically, the "E" codes in the ICD9 manual described the cause or the location of the injury but did not provide information on the vector causing the damage. The "N" codes in the manual described the body region injured but did not provide sufficient information regarding the severity of the injury. As a result, injuries of different severity were assigned the same classification (Baker,1982). An additional issue with respect to the "E" and "N" codes is that they include electrocutions, drownings, and burns. Although technically these are

classified as trauma, most studies focus on blunt and penetrating injuries.

The short-comings of the ICD9 generated the need for a method to classify injuries according to the severity. One such method was the Abbreviated Injury Scale (AIS) which will be described in the later sections. This method has been widely used in describing injury severity. It allows for the classification of over 500 injuries and includes details concerning the extent of the damage caused by the injuries.

Later in 1978, the ICD9 was modified and the new version know as ICD9-CM includes codes which provide a better differentiation between minor and severe injuries. Although the previous version of the ICD9 was not entirely compatible with AIS coding, the more recent ICD9-CM scheme provides a better link with AIS classification. Conversion tables and computer software have been developed to perform this conversion. In a recent study published by Mackenzie (Mackenzie et al.,1989) on the AIS scores for 1120 cases, the percent agreement for the maximum AIS scores obtained by conversion and by those obtained through direct chart review was 48% for head and neck injuries and 74% in extremity injuries. There was 68% agreement for grouped ISS scores.

Although this system may not be ideal, it offers substantial advantages. First, the ISS scores for large data banks may be obtained without requiring extensive chart

reviews as long as ICD9-CM codes are recorded. This will provide a valuable tool for large epidemiologic studies on trauma. Second, it reduces the subjective interpretation of clinical data often required for AIS coding by chart review, thus improving on the consistency of the AIS codes and ensuring better standardization.

One of the problems in conducting epidemiologic studies of injuries is that most of the data comes from hospital discharge records. These records provide ICD9 classification of the injuries. However, the majority of the patients with injuries are not admitted into a hospital and they are missed from such studies. As a result, any estimate of prevalence or incidence of injury may be underestimating the true parameters. Other methods of surviving for trauma patients may be through the calls placed to an emergency medical system; however, through this source trauma victims not using the system may be missed. Therefore, although the tools for identifying trauma patients and classifying injuries exist, the epidemiologic parameters of incidence and prevalence of severe injury are generally underestimated due to the diverse nature of trauma as a disease and the numerous modes that injured patients may access the medical system.

1.3.2.1.1. The Need for Injury Severity Measures

Measuring injury severity in terms of the threat to life and the potential disability is essential for development and research in trauma care. Baker identified six different purposes for injury severity measures (Trunkey et al.,1983), specifically:

1) Patient triage: Severely injured patients requiring specialized trauma care should be identified at the scene of the accident.
2) Clinical decision: Injury severity scores should provide emergency physicians and surgeons with an accurate tool for assessing the degree of injury severity and physiological damage, thus assisting them in decisions regarding appropriate care.
3) The development and planning of trauma systems. The specific trauma care requirements may be determined by accurately assessing the incidence of severe trauma.
4) Evaluation: By using injury severity measures the impact of emergency care and the outcome in different trauma care systems may be compared.
5) Epidemiologic studies: changes in injury severity may be studied.

6) Cost estimation: The cost associated with compensating for the loss of life or the rehabilitation and treatment of severely injured patients may be evaluated.

During a conference at Woodstock, Illinois in 1983, a group of approximately 30 trauma researchers defined the following criteria for the ideal injury scoring system (Trunkey et al.,1983).

1) The system has to be easy to use.
2) The implementation has to be feasible, i.e. the data should be generally available.
3) Should have reasonable face validity.
4) There should be good correlation between trauma-related disability and mortality.
5) The measure should be reliable with good inter-rater reliability.
6) The measure should be independent of the quality of care. It should therefore be applied as soon as possible after the injury or it should use information which is not amendable by pre-hospital or in-hospital care.
7) The measures should be applicable to single and multiple injuries.

Mackenzie has pointed out that regionalization of trauma care requires the implementation of categorization of hospitals and patient triage protocols. She further

emphasized that the essential requirement of patient triage protocols is a measure which can quickly and accurately assess the severity of the injury. This measure should be easily applied by emergency medical technicians (EMTs) at the scene of the accident.

The same author elaborating on the conclusions of the 1980 Conference of the National Centre for Health Services Research and the American Trauma Society has stressed the importance for the standardized measures of injury severity so that trauma care between facilities or over time could be compared while controlling for the severity of the injuries. In addition to the requirements suggested by the Woodstock conference, Mackenzie pointed out that criterion, predictive, and construct validity are essential for the ideal injury severity system.

1.3.2.1.2. Approaches to Injury Severity Determination

Injury severity measures may be classified into two main categories according to the indication of injury measured. Anatomical scales such as the Abbreviated Injury Scale (AIS) assesses the extent of the damage to the tissue. These measures integrate data acquired through physical examination, surgery, investigative procedures such as radiology and autopsy reports (Cales,1986). Given that these measures are based on hard evidence there should be high inter-rater reliability. However, the lack of adequate

data, specifically in patients who die without having a post-mortem examination, may reduce the validity of these measures. Often these measures require data which are not readily available at the time of the accident. In addition, most of the studies using these measures use hospital discharge data which are obtained only after diagnoses have been made, in-hospital treatment has been provided and all the information has been entered in the patient's chart. Therefore, these measures are not useful as patient triage tools and their application is generally in evaluation of trauma care.

The second category of injury severity measures are based on the physiological state of patients at the time of the injury; such measures are the Trauma Score (TS), the Glascow Coma Scale (GCS), and the Pre-hospital Index (PHI). Data required for such measures are readily available at the scene of the accident and can be easily obtained by emergency medical technicians before any pre-hospital care is provided.

The intent in developing such measures was to obtain indicators of the physiologic responses to injury as close to the time of the injury as possible. These measures were to be used prospectively to assess the impact of pre-hospital care. Changes in the physiological status as measured by these indices would indicate improvement or deterioration of the patient compared to the time of the

injury. However, the implementation of extensive use of these instruments in the field has not been feasible and variability of the physiological responses reduces the validity of these measures.

Furthermore, because such indices rely on subjective interpretation, the inter-rater reliability is compromised (Cales,1986). However, the availability of the data required for their computation makes these indices the best available triage tools in determining prospectively which patients require specialized trauma care.

There is a third category of severity indicators which Mackenzie has called a-priori variables, such as gender, age, and the presence of pre-existing comorbid conditions (Mackenzie et al.,1983). The Wisconsin Trauma Index, the Revised Estimate Survival Probability Index and the Trauma Injury Severity Score (TRISS) incorporate some or all of these parameters. However, as Mackenzie points out, there is considerable debate whether these parameters should be an integral part of the scoring system or whether they should be variables which are controlled for in the analysis of the data. Mackenzie suggests that age and injury severity should be measured separately because information is often required on the severity of the injury alone and not on the outcome or pre-disposing factors, and because the effect of age on mortality is different than its effect on other outcomes of injury (Mackenzie et al.,1983).

Finally, there are injury severity indices which combine anatomical, physiological and/or a-priori indicators of injury severity. These measures have been used in evaluative research because their performance is superior to either the anatomical or physiological indices alone. The TRISS index is such a measure and it has been used extensively as a tool for comparing the outcome of injury from different trauma care systems. The Trauma Index and the Wisconsin Trauma Index are other examples of composite indices.

The following sections are devoted to describing several measures of injury severity. This section is intended primarily as a reference, as these indices are mentioned throughout the remaining text. However, the comparison of these measures is beyond the scope of the thesis, as is their critique. The Injury Severity Score (ISS) has an important role as a measure used to control for injury severity and as an outcome predictor in this thesis. The advantages and limitations of this measure are discussed in detail in Chapter 5.

1.3.2.1.2.1. Anatomical Indices:

Abbreviated Injury Scale (AIS):

This scoring system was developed by the American Association of Automotive Medicine. According to this scoring scheme, the body is divided into seven regions, specifically: external, head and face, neck, thorax, abdomen and pelvic contents, spine, and extremities.

Injuries to each body region are assigned a code as described in the AIS coding manual which includes approximately 500 different injuries. Each injury code includes a rank indicating the risk of death associated with the specific injury. These ranks were determined by a consensus from a committee of experts. A rank of 1 indicates minor injury and a rank of 5 indicates extremely severe injury. A rank of 6 implies non-survivable trauma. Each body region is assigned the highest AIS score of all injuries in that region. The AIS was first developed in 1971 and has been revised in 1976, 1980, and 1985 (Petrucelli et al.,1981; Greenspan et al., 1985; AIS Manual,1985),

The Injury Severity Score (ISS)

The ISS is a derivative of the AIS developed by Baker in order to improve the ability of the scoring system in predicting mortality. The ISS is calculated by the sum of the squares of the AIS score of the three most severely

injured body regions. Thus, in order to calculate the ISS, the AIS of each region has to be determined and the three highest AIS scores are then squared and summed (Baker et al.,1974).

$$\text{Therefore:} \quad ISS = \sum_{i=1}^{3} (AIS^{*})^{2}$$

* Three highest AIS scores.

The ISS for a patient with any injury may range from 1 to 75. An ISS above 50 is considered to indicate almost certainly fatal trauma (Baker et al.,1975) whereas an ISS above 15 is considered as indicating moderate to major trauma and an ISS above 25 indicates major trauma. An ISS of 75 is automatically assigned when any injury with an AIS of 6 (fatal single-region injury) is present.

The ISS has been shown to be strongly correlated with mortality and disability (Bull,1975; Baker et al.,1974). However, the validity of the ISS may depend on the completeness of the data in the patient's chart. Insufficient data result in under scoring of the ISS. More recently, certain concerns have been raised regarding its validity, particularly with respect to prediction of mortality. One of the issues raised is that a high ISS score (> 25) may result from a single major injury (AIS = 5) or multiple minor injuries (3 * AIS of 3; => ISS = 27) for which the risk of death may not be necessarily similar. However, at the present time, the ISS is the best and most widely used summative measure instrument available for measuring anatomical injury severity.

Anatomical Index (AI)

The AI was developed by Champion by assigning probabilities of death for blunt trauma to ICD9 codes (Champion et al.,1983).

1.3.2.1.2.3. Physiological Scores:

Trauma Index (TI)

This measure involves the ranking of injuries with respect to body region, penetrating injury, cardiovascular condition, neurological status, and respiratory status (Kirkpatrick et al.,1971; Ogawa et al.,1974).

CRAMS

This is a triage oriented measure consisting of the following five parts: circulation, respiratory, abdomen, motor and speech. Each part is assigned a specific value as: normal=2, mild abnormal=1, severe abnormal=0. The range of CRAMS scores is from 0-10 with higher scores indicating better status (Cormican et al.,1982; Clemmer et al,1985).

Glascow Coma Scale (GCS)

This instrument is based on eye opening, and motor and verbal responses. It is more appropriate for patients with stroke and head injuries (Mayer et al.,1980;1984;1985).

Trauma Scores (TS)

This is the most widely used physiological index of injury severity. The TS was developed by Champion by combining the GCS with data on systolic blood pressure, capillary refill, respiration rate and respiration effort (Champion et al.,1980). Similarly with the GCS, higher TS scores indicate better status. The range of the TS is 0 - 16 with 0 - 3 indicating fatal or extremely severe trauma (Champion et al.,1981;1986;1989; Hawkins et al.,1988).

The TS has been shown to correlate well with mortality and several researchers have suggested that changes in the TS between the site and hospital may be appropriate measure for evaluating pre-hospital care (Rhee et al.,1987; Ramenofsky et al.,1988; Champion et al.,1983).

Pre-hospital Index (PHI)

This is a recently developed physiological index of injury severity which is based on consciousness, respiration, blood pressure and pulse. Based on the coefficients from regression analysis, a score is assigned for each of the components with their sum comprising the PHI. The actual PHI scores range from 0 - 20; however, an additional four points are added for penetrating abdominal or thoracic injuries. The PHI has been evaluated prospectively and it has demonstrated strong association with survival, the need for surgery and ICU treatment (Koehler et al.,1986;1987).

1.3.2.1.2.4. Composite Indices:

Trauma Injury Severity Score (TRISS)

This is the most commonly used composite injury severity index which has been applied mainly in determining expected mortality rates for samples of trauma patients. The TRISS method involves the estimation of a probability of survival on the basis of age, ISS, and TS according to specific logistic regression coefficients. The coefficients for the logistic regression are determined and periodically updated from data on patients in the Major Trauma Outcome Study (MTOS). The MTOS includes data on over 47,000 trauma victims from approximately 100 hospitals in North America (Boyd et al.,1987).

1.3.2.2. Age

Baker and Bull have presented data showing that after controlling for injury severity, the risk of dying from injury is higher for older individuals. Using data from 1300 road traffic accidents and ISS scores, Bull computed the lethal injury severity required to cause death in 50% (LD50) of the individuals in four age groups. These data showed that the lethal injury severity (LD50) decreased from an ISS of 40 for individuals between the ages of 15 to 44, to an ISS of 29 for those between 45-64 years of age, and to an ISS of 20 for victims over 65 years of age (Bull,1975; Baker et al.,1976).

Other studies have reported similar results showing that although injuries occur more often in younger individuals, the probability of dying once injured is higher in older persons, especially in those over the age of 55 (Fife et al.,1984). Naughton has shown that mortality from penetrating heart wounds increases with age (Naughton et al.,1988). Using logistic regression to control for injury type and severity, Goldberg (1983), Lokkerberg (1984), Convoy, (1988) and Kraus (1985) showed that the odds of dying from brain injury increase with age. Similar results were reported by Osler in a study comparing a group of trauma victims who were 65 years of age or older with a group of younger trauma victims (Osler et al.,1988).

Several authors have called attention to the special needs of the paediatric trauma victim, emphasizing the need for prompt and accurate assessment of the injuries and the necessity of paediatric support in trauma centres (Ruddy et al., 1985; Dykes et al.,1989; Polley et al.,1986; Walker et al.,1987; Seidel et al.,1984; Owen et al.,1983). Similarly, the elderly have been identified as a population with particular requirements for trauma care (Oreskovich et al.,1984; Osler et al.,1988; Demaria et al.,1987).

1.3.2.3. Body Region and Mechanism of Injury

The nature of the injury (blunt vs. penetrating) and the anatomical site damaged are important factors affecting the risk of dying and in determining the nature of the emergency medical care required. Penetrating injuries may cause death by causing external bleeding, whereas blunt injuries may conceal internal bleeding which could prove fatal if left untreated. Injuries to the brain are considered to be associated with a higher risk of death than injuries to other body regions (Frazee,1986). Convoy has shown that contusions or lacerations of the brain, or fractures of the skull with hemorrhage are associated with increased odds of dying ranging from 2.0 to 7.8 when compared with other types of brain injuries (Convoy et al.,1988). Baxt concluded that in patients with blunt trauma to other body regions, the presence of a brain injury increases the risk of dying (Baxt et al.,1987).

Oreskovich et al. (1984), and Osler et al. (1988) showed that in the elderly, brain injuries are associated with significantly higher mortality than other injuries. Similarly, Walker indicated that children with brain injuries have a higher risk of mortality when compared to those with injuries in other body regions (Walker et al.,1987).

Several researchers have recently recognized that patients with penetrating injuries to the head, abdomen, or

thorax require immediate surgical attention (Mattox et al.,1986). Naughton showed that penetrating injuries to the atria of the heart were associated with 100% mortality (Naughton et al.,1988). Based on data from patients with no vital signs on hospital admission, Shimazu concluded that while isolated blunt head injures had the highest rate of resuscitation, blunt multi-system injuries involving the chest, abdomen or trunk as well as penetrating head or neck wounds resulting in cardiac arrest were almost always fatal (Shimazu et al.,1983). Similar conclusions were drawn by Fielder based on data on 123 victims of gunshot wounds (Fielder et al.,1986).

Motor vehicle accidents cause the majority of the injuries in younger age groups, specifically in individuals 15-25 years old (Kraus et al.,1988; Baker et al.,1985:99-102,195-267; Waller et al.,1985:105-222). Motor vehicle accidents as a mechanism of injury, as well as falls from higher than 15 feet, are associated with a higher mortality risk due to the increased probability of multiple injuries (Baker et al.,1985:113-123; Waller et al.,1985:321-328).

In recognizing the importance of the anatomical site damaged and the mechanism of injury as outcome predictors, several researchers have suggested that these two factors should become part of the patient triage algorithm (Lowe et al.,1986; Knopp et al.,1988; Hawkins et al.,1987; Knudson et al.,1988; Cottington et al.,1988; Long et al.,1986). These

authors have shown that motor vehicle accidents (MVA) in which a pedestrian was hit and thrown, or car crashes in which a death in another person occurred, or falls from greater than 15 feet, as well as penetrating head injuries and injuries to the chest, the abdomen or multiple sites introduce increased mortality risk. They suggested that patients injured by one of these mechanisms or with injuries to these sites should be triaged to trauma centres.

1.3.2.4. Comorbidity

The importance of considering comorbidity as a covariate or potential confounder in the study of disease was noted by several authors. Kaplan and Feinstein noted the importance of classifying comorbidity for the study of patients with diabetes and developed a grading scheme to classify comorbid conditions according to their prognostic effect (Kaplan et al.,1974). Charlson developed a logistic model for determining the increased risk of death associated with specific conditions and introduced a method for including this parameter in longitudinal studies (Charlson et al.,1987). More recently, Greenfield concluded that comorbidity should be included in any assessment of the quality of hospital care (Greenfield et al.,1988).

Comorbidity has also been recognized as a factor which contributes to the risk of dying from trauma. Using crude estimates of relative risk, Goldberg showed that the

presence of ischemic heart disease, malignant neoplasms, and influenza or pneumonia increased the risk of dying in trauma patients. However, when logistic regression was used to control for patient age and sex, only the presence of ischemic heart disease was found to be associated with a significantly elevated risk for dying in trauma victims (Goldberg et al.,1983).

In a recent case-control study, Morris and MacKenzie tested the effect of 11 pre-existing medical conditions on the outcome of trauma. In this study, 3074 non-surviving trauma victims (cases) were matched with 9869 survivors (controls) on age, receiving hospital, and the type and severity of the injury. Their results showed that the presence of cirrhosis (Relative Odds (RO) = 4.7), congenital hematological disorders (RO = 3.2), ischemic heart diseases (RO = 1.8), chronic pulmonary obstructive disease (RO = 1.8), and diabetes (RO = 1.3) were significantly associated with increased odds of dying. An important finding of this study was that the impact of pre-existing conditions was higher for less severe injuries (Morris et al.,1990; MacKenzie et al.,1990).

1.3.3. Interventions Against Injuries

Interventions against injuries can be implemented before the injury (pre-injury phase), at the time of the injury (injury phase), and after the injury (post-injury

phase). In the pre-injury, phase interventions focus on preventing the release of damaging amounts of physical energy in the system, thus preventing the occurrence of the injury. In general, improved engineering and education are the main techniques for promoting injury prevention (Robertson,1983:71-80; Trunkey,1983; Waller et al.,1985:39-45).

During the injury phase, intervention focuses on attempting to separate the energy and the host, so as to minimize the energy transfer from the environment, or on improving the body's ability to withstand the damaging effect of the energy. The design of safer automobiles, and highways, the use of helmets, seat-belts, and the proper training of athletes are examples of interventions which are applied in this phase (Waller et al.,1985:39-45; Robertson,1983:71-80).

The objectives of the interventions applied during the post-injury phase are to minimize the probability of death or disability after the injury has occurred. Almost one half of all trauma deaths are not preventable in spite of the quality of the medical care (Trunkey,1983; Baker,1986). The remaining half are avoidable given prompt and adequate medical care. As will be discussed in later sections, the injuries which cause these preventable deaths require surgical or medical attention within 30-60 minutes from the time of the injury. This time period has been termed as the

"Golden Hour" or "Platinum Half Hour" (Trunkey,1983; Boyd,1983; Gold;1987) for the treatment of severely injured patients.

The onus of transporting severely injured patients to a properly equipped hospital in a physiological status with best chances of survival is on the pre-hospital system. The level of care available at a medical facility will be ineffective if the patients are transported in a deteriorated state which makes recovery unlikely. Similarly, the prompt delivery of patients is without benefit if proper care is not available at the receiving hospital. Therefore, the pre-hospital and in-hospital components of the emergency medical system are both important in reducing trauma-related death. These characteristics of the emergency medical system which influence the outcome of trauma, specifically, the time interval between the injury and definitive medical care, and the quality of pre-hospital and in-hospital medical care, are modifiable.

The time between the injury and the arrival at a hospital consists of the following components: the time from the occurrence of the injury and sounding of the alert, the response time of the emergency pre-hospital services, the time spent on the scene, and the transport time from the scene to the hospital. The time between witnessing of the event and sounding of the alert could be reduced by

implementing an efficient alert system such as the "911" telephone number. Response time can be shortened by increasing the number of ambulance automobiles or by introducing other transport means (helicopters, etc.) and extending the network of patient transport systems. Scene time can be reduced and used more efficiently by focusing on the use of less time-consuming and more effective on-site procedures. The least modifiable of these components is transport time. However, establishment of regional trauma programs with trauma centres may reduce the time between departure from the scene of the injury and transport to a medical facility capable of providing care to severely injured patients.

With respect to pre-hospital care, there is considerable debate concerning the direction of the changes that will affect an improvement in overall trauma care. As will be discussed later, controversy continues as to whether for trauma patients, on-site advanced life support is more appropriate than basic life support and immediate transport to a hospital. Resolution of this controversy should define the appropriate direction of the change in pre-hospital care, either towards minimization of on-site care and focus on expeditious methods of patient transport or maximization of on-site care involving extensive advanced life support. As the controversy is ongoing, the appropriate method of improving the effectiveness of pre-hospital trauma care is

yet to be defined.

In-hospital trauma care may be improved by establishing teams of properly trained trauma specialists recruited from the entire spectrum of medical modalities. Such a team should provide accurate and prompt diagnosis, should reach decisions regarding the proper sequence of treatment, initiate treatment immediately and finally, provide appropriate direction for long-term rehabilitation.

In summary, the previous sections outlined several factors which influence the outcome of trauma. Of these, patient characteristics such as age, and comorbidity are not modifiable. With respect to the characteristics of the injury, the severity, body region involved, the type and mechanism of injury are not readily modifiable. Design of safer automobiles or highways may prevent serious injury thus decreasing the overall severity of motor vehicle accident associated injuries. Research in this area is ongoing; however the implementation of the findings is relatively slow and their overall impact requires further evaluation. In addition, these factors would contribute to the prevention of severe injuries rather than the management of patients who have been injured.

The two basic components of emergency treatment of trauma patients, which influence the outcome, i.e. pre-hospital time and quality of in-hospital emergency care, are modifiable. With respect to in-hospital care it is widely

accepted that trauma centres staffed with highly trained trauma teams provide the best probability for a favourable outcome. However, there is considerable disagreement about the role of pre-hospital services in the care of the trauma victim. As will be discussed in the next chapter, debate about the level of pre-hospital care that is appropriate for trauma victims is continuing. The main issue of the debate is whether on-site care should be limited to basic life support followed by immediate hospital transport, or whether advanced life support should be initiated at the scene prior to hospital transfer.

1.4. PRE-HOSPITAL EMERGENCY SERVICES

1.4.1. Components of Emergency Medical Systems

The pre-hospital emergency system consists of four basic components. The first involves the witnessing of the injury event and sounding of the alert which will activate the pre-hospital medical services. The significance of this component becomes obvious in consideration of the evidence suggesting that trauma- related death and severe disability can be significantly reduced if definitive medical care is provided to the victim within approximately 30-60 minutes of the injury (Boyd et al.,1982;1983; Champion,1982; Eastman et al.,1987; Trunkey,1983). If an injury is not witnessed or if there are long delays in the sounding of the alert, the probability of providing medical care within the 30-60 minute time limit diminishes.

The second component consists of the response of the pre-hospital emergency medical services. Incorporated in this are the nature of the medical or paramedical personnel utilized, the type of on-site interventions performed, and the decision regarding the hospital to which the patient is to be transported. The time delays involved in this component, specifically, the response time, the time on scene and the transport time are important aspects of the emergency services' response.

The third component involves the transport of the patient to a hospital and the preparation by the hospital to receive the patient and to provide prompt and adequate medical and surgical care. Related to this is the emergency care provided when the patient arrives at the hospital. Essentially, the emergency room may be considered as an extension of pre-hospital care and its contribution is very important for the efficient operation of any emergency trauma care system. Therefore, research on pre-hospital trauma care should extend to the emergency care provided at the hospital and should include this component in evaluating any emergency medical system.

The coordination and communication of the pre-hospital and in-hospital care is the fourth component of the emergency medical system which is of importance in the care of trauma victims. Efficient communication and coordination will not only reduce pre-hospital delays but will reduce delays in the hospital. Such a system would ensure that the receiving hospital's staff is aware of the condition of the arriving patient and is prepared to provide the necessary care.

1.4.2. Development of Pre-Hospital Trauma Care

One of the stimuli to promote organized trauma services originated from experiences in World War II, the Korean war, and the Vietnam war, where it was observed that shorter

delays in the delivery of definitive medical and surgical care were associated with substantially reduced case-fatality rates (Boyd et al.,1983; Trunkey,1983).

In 1966, the National Academy of Sciences/National Research Council Committees on Shock and Trauma published a report which prompted the beginning of a systems approach to the organization of emergency services (Boyd et al.,1983). In 1973, the enactment of the Emergency Medical Services Act called for the implementation of regional emergency medical services (EMS) programs throughout the U.S.A. (Boyd et al.,1983). These programs include categorizing hospitals according to the level of trauma care provided, implementing patient triage protocols, organizing ambulance and other rapid transport services, training of emergency personnel and establishing communication between the various components of the system. Over 300 such programs have been established in the U.S.A.

A number of studies, some of which will be described in detail in the next chapter, have reported reductions in mortality rates associated with the implementation of such regional trauma programs. Because the majority of these studies use cross-sectional differences between geographic regions or declines in mortality rates over time to evaluate the impact of regional trauma services on mortality, secular trends or independent regional differences may confound their findings. Furthermore, it is difficult to estimate

the separate impact of each component of the emergency system on the reduction of mortality. Nevertheless, these data strongly and consistently suggest that regionalized organized trauma services reduce trauma-related mortality and disability.

Although the overall benefit of regional organized trauma programs is generally accepted, the way an emergency trauma pre-hospital service should optimally function remains controversial. The controversy arises from a paradox. Transport of a severely injured patient to a hospital within 30-60 minutes is essential to reduce the risk of death or disability; however, on-site stabilization procedures may introduce delays so that the 60 minute limit is exceeded. The dilemma therefore presented is whether it is better to transport the severely injured patient to a hospital immediately, or to first stabilize the patient on-site, and then transport to the hospital. This has become generally known as the "Scoop and Run" vs "Stay and Stabilize" controversy.

The advocates of the "Scoop and Run" school support immediate transport of severely injured patients to a hospital capable of providing adequate care and do not favour on-site stabilization or advanced life support. The main argument presented by this side is that the majority of on-site stabilization procedures used have questionable and at the best minimal effectiveness. The increased time on

the scene introduced by these procedures may increase the risk of death and disability by further delaying transportation for definitive trauma care.

In contrast, the supporters of the "Stay and Stabilize" controversy argue that the time required for on-site stabilization is relatively short and does not substantially affect the risk of death and disability. In addition, they claim that severely injured patients who are not stabilized at the scene may deteriorate severely while en-route to the hospital, thus, reducing the probability of a favourable outcome.

Studies supporting the use of advanced life support at the scene of the accident are based on small numbers of highly selected patient groups. The lack of appropriate comparison groups, as well as properly accounting for or studying the effect of confounders and effect modifiers weakens significantly the conclusions of these studies. From such studies it is difficult or even impossible to separate the impact of advanced life-support as a whole from the effect of temporal factors, other procedures, other components of the emergency medical system, and the level of in-hospital care. In addition, the conclusions reached by these studies are often weakly supported by the data presented and their arguments are scientifically weak.

Supporters of the "Scoop and Run" side report studies failing to demonstrate any benefit from advanced life support. It should be noted however, that it is easier to demonstrate a null effect especially in the area of trauma where the observed impact will be relatively small. The majority of the negative studies also rely on small numbers, which may raise concerns about statistical power. However, their negative findings are better supported by their data as compared to the studies presented by proponents of "Stay and Stabilize". Still, the debate continues and further scientifically rigorous studies are required.

1.4.3. The Need for Evaluation

In spite of the controversy and the fact that in recent years the weight of the evidence has favoured the "Scoop and Run" approach, several communities, including that of Montreal, have implemented pre-hospital emergency services which utilize on-site stabilization and advanced life-support procedures for severely injured patients. These programs have become widely accepted by government bodies and medical professionals since the enthusiastic move towards pre-hospital treatment of trauma victims that first began around 1967. This acceptance has helped maintain such programs in spite of the lack of rigorous evaluation. In fact, of all the on-site procedures utilized, only pneumatic anti-shock trousers (PASG) have been evaluated in

prospective controlled trials. The results of these studies which are presented in more detail in the next chapter, suggest a null or harmful effect for this apparatus. Studies properly evaluating other on-site procedures are lacking.

The general opinion is that with the exception of intubation for the management of an obstructed airway and the maintenance of respiration, other on-site advanced procedures such as intravenous line initiation, and medication administration are of questionable effectiveness. None of these three interventions have been properly evaluated.

1.4.4. Methodological Issues in Evaluating Pre-hospital Trauma Services

Given the questionable effectiveness or even the potential harmful effect of on-site pre-hospital advanced life support interventions for severely injured patients, and the cost of maintaining EMS programs incorporating these procedures, the evaluation of such systems is a top priority. It is essential that research in this area focuses on studies which could provide reproducible and valid estimates of the impact of advanced life-support interventions on the outcome of trauma.

While recognizing the lack of such studies and the necessity for such research, it must be acknowledged that studies evaluating pre-hospital trauma services which are compatible with the classical randomized controlled design will most likely be prohibited by ethical, political and practical barriers. Nevertheless, non-experimental studies of the survey, impact type design utilizing naturally occurring variations in pre-hospital trauma care could be used to evaluate the impact of pre-hospital trauma services on the outcome of trauma.

The majority of the early studies evaluating trauma care reported in the literature have used the "preventable deaths" concept as a measure of the effectiveness of trauma care systems. This methodology was first used with autopsy reports and involves the classification of each death in the study as preventable or non-preventable. The rate of preventable deaths is then used as a measure of effectiveness.

Although widely used, the preventable death methodology introduces several problems: first, that the definition of a preventable death is rarely determined objectively and a priori; second, that the case-mix differs from study to study and that often selected groups of patients are used; and third, that these studies focus on non-survivors, and thus measure only the failures of the system while not considering the successes (lives saved). Salmi et al.

reviewed studies using preventable deaths as a measure of outcome in the evaluation of trauma care systems. They noted that variations in preventable death rates may be statistical artifacts introduced by variations in the definition of preventable deaths or in the case-mix rather than a function of improved trauma care. They also point out that if referral patterns were such that the more severely injured patients were transported to trauma centres, the proportion of deaths classified as non-preventable will be increased in these facilities. Consequently, the rate of preventable deaths would be decreased regardless of the quality of care available (Salmi et al.,1986). As a result, data from different such studies are not comparable and their conclusions have limited applicability to other populations.

Another methodology in evaluating trauma care systems involves indirect standardization. Comparisons of expected and observed mortality yield a measure of the system effectiveness. The critical issue in such studies is the choice of the standard population. Champion et al. have introduced a method of comparing the study population to that of the Major Trauma Outcome Study (MTOS) which includes data from approximately 100 hospitals in USA and Canada (Boyd,1987; Champion et al.,1981,1989). Although certain problems may arise specifically with respect to comparability of the study and standard populations, this

method may be preferable to the preventable death method in that the terms and definitions are standardized and comparisons across systems and studies are possible.

1.5. THE PRESENT STUDY

1.5.1. Emergency Medical Services in Montreal

In 1987, Montreal and Laval comprised of a metropolitan area of 3508.89 km^2 with a population of 2,995,600. Urgences-Santé is the only emergency medical system serving these two cities (Appendix F).

In 1981, the Montreal Regional Council for Health and Social Services founded Urgences-Santé, a division within the Regional Council whose mandates are; 1) to coordinate pre-hospital emergency services; 2) to coordinate ambulance transport; 3) to plan the emergency room use in collaboration with hospitals; and 4) to exercise control over admitting policies and data collection on the regional availability of hospital beds. Since that time, the management and control of pre-hospital medical services in the Montreal and Laval regions have been the sole responsibility of Urgences-Santé. Thus, the first two objectives have been at least partially met; however, the latter two have yet to be addressed.

Prior to the creation of Urgences-Santé, pre-hospital emergency care in Montreal was provided by privately owned ambulance companies and by police ambulances. Medical care at home was also provided by physicians who co-operated with the private ambulance companies. The lack of coordination of these pre-hospital services prompted the creation of Urgences-Santé. The new system introduced with Urgences-

Santé maintained the availability of physicians to provide on-site care; however, it was necessary to introduce means of controlling the costs of the system by limiting the use of physicians to appropriately urgent cases. A triage mechanism was therefore introduced. Nurses were trained to screen telephone calls to Urgences-Santé and identify cases where a physician would be required.

At present, all "911" telephone calls requesting emergency medical services are received by nurses who are located at the main Urgences-Santé facility. The nurses are trained to assign a priority rating to the call and to obtain information which is used to determine the severity of the injury or illness. The nurse then decides what resources are required at the scene. The resources may be nothing at all, an ambulance with an emergency medical technician (EMT), or an ambulance with an EMT and a physician (MD). In 1987, there were 15 full-time and 60 part-time nurses, 700 EMTs and 200 MDs employed by Urgences-Santé.

The requests from the nurses are then directed to the dispatchers who coordinate the mobilization of the available ambulances, EMTs, and MDs to the site. The reception of calls and dispatching takes place at the main Urgences-Santé location. Ambulances, EMTs and MDs are assigned to standby points whose location changes according to the time of day, day of the week, and the demand. The locations are moved

towards the downtown area during the working hours and towards the suburbs in the evening. In addition, the number of these mobile units available is increased during the afternoon when demand is highest.

Although 10% of the EMTs employed by Urgences-Santé are trained paramedics, they are not recognized health-professionals in Quebec. They therefore are prohibited from using their advanced life support skills and are limited to the use of basic life support (BLS), specifically, patient extrication, immobilization of head and spine, dressing of wounds, splinting of fractures, administration of oxygen and cardiopulmonary resuscitation. Urgences-Santé MDs perform both BLS and advanced life support (ALS) procedures including establishment of intravenous lines (I.V.), endotracheal intubation, administration of medication and application of pneumatic anti-shock garments (PASG).

Almost all cases of severe trauma will require an MD. However, for approximately 25% of these cases an MD is not available and only an EMT with an ambulance is dispatched. This introduces variation with respect to the types of services dispatched to the site and patients with similar injuries may receive different levels of on-site care. In addition to this source of variation, the procedures applied by physicians at the scene also vary. Thus, patients who are seen by a physician may be provided a full spectrum of on-site care ranging from no interventions at all to basic

life support or advanced life support including intubation, I.V. initiation, medication, and PASG application.

Urgences-Santé is unique in North America in that MDs are employed by the emergency system and are dispatched to the accident site to provide pre-hospital care. Although there are other communities where physicians provide emergency medical care in aeromedical units, they are not part of the emergency system as they are in Montreal. The fact that Urgences-Santé MDs provide on-site care to critically injured patients makes this setting highly appropriate for the evaluation of the impact pre-hospital care on the outcome of trauma.

In view of the controversy regarding the appropriateness of advanced life-support (ALS) for trauma victims and the concerns as to whether EMTs should be further trained to provide such care, an evaluation of ALS in a setting such as that found in Montreal is highly relevant. If the effectiveness of on-site pre-hospital advanced life-support interventions performed by physicians in reducing trauma mortality is not convincingly demonstrated, the weight of evidence would shift even more towards the "Scoop and Run" school of thought and there would be little purpcse in training EMTs to offer such services. Such a study has not been conducted.

Since its creation, there has not been a study which describes or evaluates the impact of the Urgences-Sante system on the outcome of trauma in Montreal. Such a study

is necessary in order to compare the Montreal system with others in North America with respect to the response times effectiveness, the quality of care, and the overall impact of the system in reducing trauma-related mortality.

1.5.2. In-hospital Emergency Trauma Care in Montreal

There are 33 acute-care hospitals in the Montreal area. Of these, 11 are affiliated with one of the two Montreal universities with medical schools and serve as teaching hospitals. Formal classification of the Montreal hospitals according to the level of trauma care has not been implemented to this date. In addition, patient triage protocols calling for the transfer of critically injured patients to specific hospitals have not been applied formally. Finally, communication between receiving hospitals and Urgences-Santé ambulance aimed at preparing the hospital to receive the patients is not in effect. Therefore, patients are being transferred to the nearest available hospital generally without consideration of the patients' specific needs.

The 11 teaching hospitals have a 24-hour coverage by at least an emergency physician and in some cases a surgeon capable of providing adequate care to critically injured patients. However, none of the hospitals are recognized or are organized as trauma centres incorporating a full integrated trauma team including a surgeon, anesthesiologist

and nurse a specializing in the care of trauma. The 22 hospitals which are not affiliated with a university have minimal or negligible trauma care available at all times.

The lack of trauma care regionalization in Montreal introduces another element of variation in the care of a trauma victim, specifically that of the in-hospital emergency care. Patients with similar injuries could theoretically be treated at any of the Montreal hospitals. This provides the opportunity to assess the impact of the level of in-hospital care on the outcome of trauma victims.

1.5.3. Rationale

The preceding sections summarized the theories of injury causation and injury control. The impact of injuries on society was discussed and the methods implemented to counteract the effects of injury were briefly presented. In addition, several issues concerning the need for further research in emergency trauma care in general and specifically for the Montreal area were highlighted. These issues are as follows:

1) Urgences-Santé has coordinated and managed pre-hospital emergency services in Montreal since 1981. This emergency medical system is unique in North America in that emergency physicians may be dispatched to the scene to provide pre-hospital

care to severely injured or ill patients in an urban setting. In addition, although some hospitals in the area may be capable of providing high level trauma care, none of the hospitals are formally designated or organized as trauma centres. Formal patient triage protocols for the transfer of critically injured patients to better equipped hospitals are not in effect. Thus, Montreal provides a unique setting in which varying levels of pre-hospital and in-hospital components of trauma care are available. The impact of emergency medical care in general, and each one of these components independently on trauma-related mortality may be assessed. However, a study describing and evaluating emergency trauma services in Montreal has not yet been conducted.

2) Although the effectiveness of advanced life-support in improving the outcome of trauma is controversial, several systems have been implemented that provide advanced life-support to critically injured patients. In Montreal, on-site advanced life-support procedures are performed by emergency physicians employed by Urgences-Santé who may be dispatched to the scene of the injury. Because the evaluation of the impact of on-site

advanced life-support on trauma is controversial, studies on this topic are a priority. Such a study should use a methodologically rigorous design that estimates the effect of advanced life-support procedures while controlling for other factors known to influence the outcome of trauma such as patient characteristics, injury severity, and other components of the trauma care system. Although no such study has yet been reported, it would substantially contribute to the knowledge surrounding the "Scoop and Run" vs "Stay and Stabilize" controversy.

1.5.4. Objectives

1) To describe the Emergency Medical Services System of Urgences-Santé in Montreal as it is related to trauma;
2) To describe and estimate the impact of the emergency medical services in general, and the pre-hospital and in-hospital components on trauma-related mortality in Montreal.
3) To describe and estimate the association between on-site ALS provided by Urgences-Sante physicians and the risk of dying in severely injured patients.

CHAPTER 2. REVIEW OF THE LITERATURE

INTRODUCTION

This chapter is devoted to the review of the literature on emergency trauma care. The first part of the chapter outlines the historical background and the development of trauma care systems. Studies supporting a systematic approach to trauma care are reviewed.

The second part of the chapter focuses on the pre-hospital management of trauma. Studies on both sides of the "Scoop and Run" vs. "Stay and Stabilize" controversy are reviewed and discussed in some detail. In addition, studies on specific on-site maneuvers related to trauma are also reviewed. The last sections of this part outline the literature evaluating the use of physicians at the scene of the accident. The information presented in this chapter expands on the issues already outlined in Chapter 1. The review of the studies in each section is summarized in tables which are intended to present the basic points of these studies.

2.1. THE SYSTEMS APPROACH TO TRAUMA CARE

2.1.1. Historical background

In recognizing the need for prompt care of injured warriors, the ancient Greeks set up medical care facilities near battlefields. In the 19th century, Napoleon's chief surgeon introduced the concept of an ambulance in order to expedite the provision of medical care to wounded soldiers (Trunkey,1983). More recent military experiences have further supported the contention that trauma mortality can be reduced if adequate medical care is provided promptly.

Several authors have presented observational data from recent military conflicts which show that the case-fatality rate dropped from 8.5% in World War I, where the delay between injury and medical care ranged between 12 and 18 hours with an estimated average of 10 hours, to 1.7% during the Vietnam conflict, where the average time to medical care was 65 minutes (Table 2.1) (Trunkey,1983; Boyd et al.,1983). A number of factors contributed to the decrease in mortality observed between these conflicts including the overall improvement and organization of the provision of medical care to the wounded. The most noticeable decrease in mortality rate occurred during the Korean conflict with the introduction of a system of trained paramedics, effective communications, transport of injured soldiers by helicopters, and specialized medical and surgical facilities known as Mobile Army Surgical Hospitals (MASH) (Trunkey,1983; Boyd et al.,1983).

With respect to these data, however it is not possible to isolate the independent effect of reduced time to medical care and improved surgical care on reducing mortality from other factors, including the change in the nature or severity of the injuries. However, the point that is worth noting is that the force for the development of civilian organized emergency medical services and specialized emergency trauma care originated to a large extent from these experiences and was supported by such data.

2.1.2. Development of Trauma Care Systems in the U.S.A.

The wartime systems of trauma care mentioned in the previous sections became the general model for civilian trauma care systems encompassing both pre-hospital and in-hospital care (Trunkey,1983; Boyd et al.,1983, Eastman et al.,1987; Gold,1987; ACEP,1987). In 1966, the National Academy of Sciences/National Research Council published a document entitled "Accidental Death and Disability: The Neglected Disease of Modern Society", which outlined the need for the development of improved and organized trauma care programs, and provided recommendations towards this point (Boyd et al.,1983). As a result, several pilot emergency medical service (EMS) systems were established in various parts of the U.S.A.

The impetus generated by these pilot studies resulted in the enactment of the Emergency Medical Services Act in

1973 which was later amended in 1976 and 1981. This legislation provided guidelines regarding the training of para-medical and medical personnel, establishment and maintenance of communication systems, and improvement of hospital care. The categorization of the hospital facilities according to the level of trauma care available, the education and certification of paramedics, and the implementation of protocols regarding the triage and transfer of critically injured patients are the components of the EMS Act pertaining to trauma (Boyd et al.,1983). As a result of this law, 303 regional EMS geographic areas where trauma care was considered a priority were designated in the United States. The hospitals in these regions were classified into three categories according to the level of trauma care provided. This classification was based on the standards established by the American College of Surgeons (Boyd et al.,1983; ACS,1986) (Table 2.2). Similarly, the paramedics were classified according to the 1983 National Registry of Emergency Medical Technicians (Table 2.3).

Recommendations for a regional trauma system include a centralized control and communication centre located at a medical facility, most often a level I or II trauma centre. The sounding of the alert is usually through a central system such as the "911" telephone number, and dispatching of pre-hospital personnel is coordinated at the controlling centre. Paramedics at the scene provide pre-hospital basic

life support and advanced life support is generally provided under direct communication with a physician located at the controlling centre. In systems with aeromedical pre-hospital care, a physician and a nurse may be transported by helicopter to provide advanced life support at the scene of the accident and en-route to the hospital. Regionalization of trauma care calls for the transfer of critically injured patients to designated trauma centres, thus bypassing other less specialized facilities. Communication between the receiving facility and the on-site paramedics ensures that the trauma centre staff is prepared to receive the patient by mobilizing in-house and on-call personnel and preparing the operating or other facilities and equipment as necessary (ACEP,1987).

Since the early 1970's, approximately 100 regional trauma systems have emerged in the United States according to the guidelines stated in the EMS Act. Studies supporting the need for organized trauma care and evaluating the effectiveness of such trauma care systems in reducing trauma mortality have been steadily appearing in the literature. This literature will be summarized in the next section.

2.1.3. Issues in Trauma Care Research

The most comprehensive presentation of the rationale for the development of organized trauma care utilizing a systems approach has been presented by Trunkey. In a 1983

Scientific American article, Trunkey developed his arguments by discussing issues that delineate fundamental principles in the area of trauma care research. Using data from a sample of 862 trauma deaths from San Francisco General Hospital, Trunkey demonstrated that the distribution of time to death from injury is trimodal. The first peak, representing "immediate deaths", includes approximately 50% of all trauma deaths. They occur instantaneously or within one hour from the time of injury, with the majority occurring in the first 30 minutes. The immediate deaths are mostly caused by fatal lacerations of the brain, the brain stem, the spinal cord, the heart, or major blood vessels. Trunkey notes that the majority of these deaths are non-preventable.

The second peak represents approximately 30% of all trauma deaths, which occur between the first few hours and one week from the time of the injury. These deaths are generally caused by major haemorrhaging injuries, multiple injuries resulting in severe blood loss, or severe neurological and brain damage. Trunkey contends that the majority of these deaths are preventable given the current state of medical science and technology. However, the time period between injury and definitive medical or surgical care, as well as the quality of medical care, are the most significant determinants of the outcome of such injuries.

According to Trunkey's discussion, the third category of trauma deaths are classified as "late deaths" and comprise the deaths that occur several days or weeks post-injury. The majority of these deaths are caused by later complications including multiple organ failure and infections. These deaths constitute 20% of the total trauma fatalities and the onus on preventing these events is on the quality of long-term in-hospital care rather on emergency medical care. The reasons for which trauma victims are at high risk for developing infections and system failure are not known (Trunkey,1983).

Trunkey noted that patients with haemorrhagic injuries require surgical care, within 30 minutes and that neurosurgical care, for brain injuries within four hours is imperative. He argues against any attempts of on-site stabilization, especially the use of intravenous lines. In a summary of data, he concluded that the mortality of critically injured patients treated in specialized regional trauma centres within organized trauma care systems, is less than the mortality observed among patients treated in other less well organized systems and facilities (Trunkey,1983).

2.1.4. Studies Supporting the Need for Improved Trauma Care

2.1.4.1. Review of the Studies

Trunkey concluded that a definite need exists for the improvement of trauma care in North America. In spite of the existing knowledge, only a small number of communities have implemented integrated trauma systems.

Other authors have presented data supporting the need for systems approach to trauma care. These studies are reviewed in the next section and are summarized in Table 2.4. Lowe et al. reported a preventable death rate of 25% in 135 motor-vehicle accident deaths occurring in an Oregon community with 29 non-designated hospitals and without patient triage protocols. The care provided was considered to be inappropriate for 16% of the 659 victims in the study. Delays in consults, in surgical intervention, and emergency room assessments were the main deficiencies in one half of the patients with inappropriate care. The authors concluded that improved outcome in 10% of the victims would be expected if care compatible to a level I trauma centre had been available (Lowe et al.,1983).

Similarly, Bolta suggested that 43% of the 279 pre-hospital motor vehicle accidents related deaths occurring in the Sudbury district of Ontario may have been prevented if organized and adequate pre-hospital care had been available (Bolta et al.,1986). Dove reported that 55 (51%) of 108 trauma deaths occurring over a five-year period in New York were attributed to deficiencies in emergency medical care

(Dove et al.,1980).

A preventable death rate of 53% in 100 pediatric trauma deaths was reported in South Alabama by Ramenofsky (Ramenofsky et al.,1984). Initial identification errors occurred in 79% of the salvageable deaths in this study. Field care errors occurred in 36% and transport errors were noted in 23% of these fatalities respectively (Ramenofsky et al.,1984). Although reporting a lower rate of preventable pediatric trauma deaths (15-20%), Dykes from Toronto also concluded that organization of trauma care could reduce mortality by avoiding survivable deaths (Dykes et al.,1989).

Using autopsy reports from 246 non-CNS related deaths, Kreis et al. concluded that 21% of these were preventable (Kreis et al.,1986) and similarly Campbell reported that 14 (23%) of 62 non-CNS deaths were avoidable (Campbell et al.,1989). The lack of or delay to adequate surgical care was considered as the cause for the majority of preventable deaths in these studies. However, Kreis showed that the preventable death rate was significantly lower ($p < 0.01$) in level I compatible hospitals as compared to other facilities (12% vs 26.4% respectively) (Kreis et al.,1986).

2.1.4.2. Summary

The studies reviewed in the previous section strongly suggest that lack of an integrated trauma care system results in mortality rates which exceed those expected,

according to the severity of the injuries. The data from these studies demonstrated that lack of trauma care organization and regionalization as well as lack of patient triage protocols compromised the effectiveness of the existing emergency services in reducing trauma mortality. The general conclusion is that integrated trauma care systems incorporating coordinated pre-hospital and advanced in-hospital trauma care as well as centralized control and efficient communications is essential in effectively reducing trauma-related mortality. In spite of the methodological short-comings associated with the use of preventable deaths as an outcome in several of these studies, the consistency of the findings and the reported increased mortality associated with lack of adequate care provide strong support for this conclusion.

The need for improved trauma care is not unique in North America. Although Trunkey has praised the West German trauma care system (Trunkey,1983), Anderson reported a preventable death rate of 20 to 30% of 1000 consecutive injury deaths from England and Wales (Anderson et al.,1988). Similarly, Gilroy from Ireland reported that 16% of 105 deaths due to blunt trauma were caused by failure to diagnose or adequately treat major lesions (Gilroy,1984).

2.1.5. Studies evaluating trauma care systems.

2.1.5.1. Review of the Studies

The importance of organized trauma care in preventing trauma mortality has been supported by studies indicating the need for improvement in trauma care as those reviewed in the previous sections. Support for this conclusion has also been presented by studies evaluating organized trauma care systems. These studies are summarized in Table 2.5 and are reviewed in this section.

In 1974-75, West and Trunkey evaluated autopsy reports of 92 consecutive motor vehicle accident trauma deaths in San Francisco and 90 similar deaths occurring in Orange County. In San Francisco, trauma victims were transported to a centrally located regional trauma centre whereas in Orange County, trauma victims were transported to 39 different hospitals, only 31 of which had around-the-clock emergency room coverage by a physician (West et al.,1979).

A panel of experts classified deaths as preventable, potentially preventable, and non-preventable. Of the 60 CNS deaths occurring in Orange County, 17 (28%) were considered as preventable or potentially preventable. Only 2 (3%) of the 76 CNS deaths in San Francisco were considered as potentially preventable and both were cases of elderly individuals who died of pneumonia. Of 30 deaths from non-central nervous system (CNS) injuries in Orange County, 11 (37%) were classified as preventable and 11 (37%) as potentially preventable. The single preventable non-CNS

death at San Francisco occurred 10 days post-injury due to complications. The differences in preventable deaths were observed in spite of the significantly higher severity of the injuries in San Francisco (mean ISS; non-CNS: 45; CNS: 46.5) compared to Orange County (mean ISS; non-CNS: 37; CNS: 38).

The authors noted that in Orange County only 12 (20%) of the 60 CNS fatalities received neurosurgical care compared to 55 (72%) of the 76 such deaths in San Francisco. Furthermore, in Orange County, undiagnosed cerebral hematomas caused eight of the CNS-related deaths and an additional 9 were caused by inadequately treated mild or moderate head injuries (West et al.,1979).

Subsequent to this study, a regional trauma care system with five trauma centres (one level I and four level II) was established in Orange County (Trunkey,1983; Cales,1984). In 1984, Cales reported the results of a study on 58 motor vehicle accident related deaths occurring during the 1977-78 period or before the system implementation, and 60 such deaths occurring during 1980-81 or after system implementation. The results of this study showed that for both years of system operation, the observed mortality rates were significantly lower compared to the rates expected assuming no effect of the system (1981: $p < 0.03$, 1982: $p < 0.02$).

Of the 58 deaths in this study that occurred prior to system implementation, 20 (34%) were judged to be potentially salvageable compared to 9 (15%) of the 60 fatalities occurring after system implementation ($p < 0.02$). The time delay between injury and surgical treatment decreased from an average of 40 minutes during the non-system period to an average of 18 minutes during system implementation. Furthermore, the authors reported a 12-fold increase in the proportion of adequate surgical interventions for patients requiring such treatment during the later period. In addition, only 4% of the deaths occurring in trauma centres during the second period were considered preventable as compared to 54% of the deaths occurring at non-trauma centres.

Four studies from San Diego have examined the impact of a progressively developing trauma care system in that region. In the first study, Klauber et al. reported a significant reduction in population death rates from head injury deaths from 21.3-23.8 per 100,000 during 1976-80 to 19.5-17.5 per 100,000 during 1981-82 when an organized air and ground patient transport program was implemented (Klauber et al.,1985). These authors reported that the decline was statistically significant after controlling for injury severity and for the differences in the incidence of head injuries between the two time periods. Data presented in this study also showed an increase in the injury severity and a decrease in the rates of deaths occurring at the scene

and upon arrival at the hospital during the later period.

The authors concluded that the decrease of head injury related mortality was attributed to the overall decrease in the time between injury and definitive care which resulted from the implementation of organized patient transport. However, improvements in hospital care must be considered as a factor contributing to the improved outcome.

In 1984, trauma care was regionalized in San Diego and one level I, one pediatric, and four level II trauma centres were established. Medical audit data from 341 trauma patients cared for in non-regionalized facilities before system implementation and from 1366 patients treated at trauma centres after regionalization were used by Shackford in 1986 to evaluate the impact of regionalizing trauma care in San Diego (Shackford et al.,1986). The overall mortality rate was significantly ($p < 0.01$) lower in the second sample (n = 112, 8.2%) compared to that of the pre-regionalization sample (n = 90, 26.4%). Reduced mortality (19.4%) was also observed in a sub-sample of 576 more severely injured patients, from the second period, with injuries comparable in severity to those of the patients in the first sample. In this study there were 19 (21.6%) potentially or frankly preventable deaths in the first period, compared to 11 (9.8%) in the second period ($p < 0.01$). Delays in initial evaluation and in emergency room disposition were observed respectively in 41% and 54% of the patients in the first period sample as compared to 11% and 7.5%, of the patients

in the second period sample ($p < 0.01$). The audit data revealed sub-optimal assessment during the initial hospital phase for approximately 30% of the patients in the first sample compared to 2% of the second sample patients ($p < 0.01$).

A third study evaluating the San Diego regional trauma care program was reported by the same author in 1987 (Shackford et al.,1987). In this study, the observed survival of 29.1% in 189 severely injured patients (TS $\leq$ 8) was significantly higher than that of 18.1% predicted by applying the TRISS method. Finally, in a more recent study, Guss confirmed the findings of Shackford by reporting a significant reduction in preventable trauma deaths to 1% (2 out of 211) in 1986 when regionalization was in operation from 11.4% (20 out of 177) during 1979 when the system had not been implemented ($p < 0.001$) (Guss et al.,1989).

In 1977, Mullner reported an evaluation of the Illinois Trauma program which was established in 1972 (Mullner et al.,1977). The authors compared motor vehicle accident case-fatality rate data for the two-year period (1970-71), before system implementation, and the two-year period (1972-73) after system implementation.

The results reported in this study showed that the case-fatality rate for patients treated in trauma hospitals significantly decreased from 114.9 ($n = 992$) prior to system implementation to 84.6 ($n = 958$) after system implementation ($p < 0.05$). However, the case-fatality rates for non-trauma

centre hospitals was the same during the two time periods. Interestingly, the case-fatality rates for the trauma and non-trauma hospitals during the non-EMS period were also similar (114.9, n = 992 and 115.2, n = 1866, respectively). The authors conclude that the organization and coordination of pre-hospital trauma care improved the outcome in critically injured patients who were treated in hospitals with trauma centres. However, lack of coordination with pre-hospital services compromised the effectiveness of the trauma centres.

Several other authors have reported data suggesting that implementation of organized trauma care improves the outcome from severe injury. In 1983, Haller suggested that a regional pediatric trauma centre improved the outcome in terms of survival and decreased disability in severely injured children (Haller et al.,1983). In an early 1973 study from Florida, Waters reported data indicating that mortality rate from motor vehicle accidents deceased after implementation of an emergency medical care system (Waters et al.,1973). In 1983, Fortner suggested that the mortality from 50m falls decreased as a result of improved pre-hospital and in-hospital trauma care (Fortner et al.,1983).

2.1.5.2. Summary

The results of the studies reviewed in this section have demonstrated that the implementation of organized trauma care systems improved the quality of trauma care and resulted in reduction of trauma-related mortality and disability. Certain methodological shortcomings of these studies, especially with respect to the definition of preventable deaths as well as the selection and number of subjects, must be taken into consideration. Furthermore, the majority of these studies compare the outcome of trauma for two geographical locations or two time periods, it is therefore difficult to isolate temporal or geographical effects on trauma outcome from those of the implementation of a trauma care system. In addition, it is often difficult to demonstrate comparability of the trauma victims in two time periods or geographical locations with respect to injury severity as well as other factors that may affect the outcome of trauma, including injury type and mechanism of injury.

In spite of these issues, the general and consistent conclusion from these studies is that implementation of trauma care systems improves overall trauma care by improving the quality of in-hospital care and reducing the time to definitive in-hospital care. These improvements subsequently result in reduced trauma-related mortality observed in these studies.

Pre-hospital trauma care is improved by using properly trained paramedics and by decreasing response times, while in-hospital care is improved by the availability of a 24-hour coverage by trauma care teams consisting of highly trained surgeons, anesthesiologists, and nurses. The coordination of the pre-hospital and hospital services by effective communication methods, as well as the centralized control of the overall system, have contributed to the improvement of the overall efficiency of the systems.

Cales pointed out that improving trauma care quality involves the reduction in delay to definitive care which requires regional trauma care systems (Cales et al.,1987). The study by Mullner demonstrated that the mortality in trauma centres without regionalization was not significantly lower than that observed in non-trauma centre hospitals. However, a significant reduction was noted in these trauma centres following trauma care regionalization (Mullner et al.,1977). Several other studies supported the need for complete integration of the pre-hospital and in-hospital care by indicating deficiencies in systems where the components of the system (such as trauma centres or patient-transport programs) existed without being fully organized,coordinated, and integrated (Kreis et al.,1986; Campbell,1989; Dykes,1989).

In addition, Sloan and Pepe have shown that by-passing local hospitals in order to transfer patients to a regional

trauma centre increased total pre-hospital time non-significantly by an average of only three minutes (Sloan et al.,1989; Pepe et al.,1987). These findings support the transport of critically injured patients to a trauma centre, especially in consideration of the improved care available at trauma centres.

The results from the studies reviewed in this section support the statement by Gold defining trauma care integration as incorporation of field evaluation, patient triage, communications, transportation, in-hospital management, education, training of medical and paramedical personnel, and care evaluation and that a deficiency in any of these components will prove detrimental to the system as a whole (Gold,1983). These studies further support the statements of Trunkey (1983;1984) and others (Boyd et al.,1983; Maull et al.,1977): that integrated organized trauma care systems are the only solution in avoiding unnecessary trauma mortality.

2.2. ADVANCED LIFE SUPPORT IN PRE-HOSPITAL TRAUMA CARE

Following the enactment of the EMS Act in 1973 and the implementation of regional organized emergency medical systems, it was shown that provision of advance life support at the scene reduced the mortality from out-of-hospital cardiac arrests. Paramedics were trained and ambulances were equipped with the necessary instrumentation to provide advanced cardiac life support at the field. Based on results of benefit for cardiac arrest victims, it is assumed that on-site advanced life support would also be beneficial for trauma victims (Bodai et al.,1987; Gold,1987).

Consequently, various advanced life support procedures and equipment were appended to the pre-hospital trauma care protocols. Paramedics were thus trained to intubate, initiate intravenous lines, and administer medications to trauma patients at the scene of the injury under radio contact direction from physicians. The use of pneumatic antishock garments (PASGs) was incorporated by legislation in all organized emergency medical systems and PASGs were included as mandatory equipment in ambulances. Basic life-support procedures, including wound dressing, spine immobilization, fracture splinting, and patient extrication, were also routinely performed by paramedics without contact or direction by a physician.

In some European communities such as France (Hervé et al.,1989), and Sweden (Ottonson et al.,1984) as well as in Montreal, on-site advanced life-support is provided to critically injured patients by physicians. In the United States, physicians and nurses staff helicopters transporting critically injured patients, thus providing advanced life support at the scene and en-route to the receiving hospital (Baxt et al.,1983;1987; Schiller et al.,1987; Schwab et al.,1985, Carraway et al.,1984).

Although a consensus exists regarding the optimal organization of trauma care systems, and the need for advanced medical and surgical care in hospital trauma centres, a controversy and debate regarding the exact function of pre-hospital trauma care has arisen. The primary objective of the pre-hospital components of trauma care is to expedite the provision of definitive medical care to the critically injured. It is generally accepted that adherence to the "golden hour" or in some cases "platinum half hour" principle for the provision of definitive care is essential in reducing trauma-related mortality and disability (Trunkey,1983; Boyd et al.,1983). According to this principle, critically injured patients should receive surgical and medical care within 60 minutes from the time of the injury. For very severely injured patients, particularly those with rapid blood loss, the "golden hour" is reduced to 30 minutes (Trunkey,1983).

The rationale for implementing on-site ALS trauma services is to introduce definite medical care at the scene of the injury, and to stabilize the patient prior to hospital arrival. The counter position is that neither the beneficial effect of overall ALS for trauma victims, nor the effectiveness of individual ALS procedures currently used for on-scene trauma care, has been demonstrated in properly designed evaluative studies. Furthermore, and most importantly, opponents of on-scene ALS in trauma contend that the time required to perform ALS procedures will unnecessarily increase the time between injury and provision of definitive care beyond the dangerous limit, thereby increasing the risk of mortality and disability. The "Stay and Stabilize" versus "Scoop and Run" controversy has received considerable attention. The following section summarizes the studies addressing this issue.

2.2.1. Studies Evaluating On-site Trauma Care

2.2.1.1. Stay and Stabilize

2.2.1.1.1. Review of Studies

Studies supporting the use of on-site ALS are reviewed in the following section and are summarized in Table 2.6.

In 1982, Hedges, Sacco, and Champion from Washington, evaluated the outcome of 163 patients with blunt injuries (Hedges et al.,1982). These patients were provided advanced trauma life support (ALS) by paramedics trained to perform

endotracheal intubation, intravenous line establishment, administration of medication, and application of PASGs with or without supervision by a physician. The results of the study focused on 126 patients who were taken to the major trauma referral hospital in the region. The observed single death was significantly lower than that predicted by two (AI, ISS) of the four injury severity indices used. The authors conclude that the provision of ALS at the scene resulted in significantly lower mortality than was expected.

A few points should be considered however. First, it is surprising that only one death (1/126 = 0.07%) occurred in this sample in spite of the fact that these patients were referred to a major trauma centre and definitive hospital care was delayed for as long as 90 minutes. This suggests the possibility of selection bias or a very low injury severity for this sample with a small proportion of major trauma cases.

In another retrospective study using a historical control group, Aprahamian et al. evaluated the impact of the initiation of an ALS paramedic program in Millwaukee (Aprahamian et al.,1983). In this study, the authors compared the outcome of 64 patients with major intra-abdominal penetrating trauma who were injured prior to the initiation of the ALS program, to that of 48 patients with similar injuries who were injured after the program was implemented. The results of this study showed that overall

mortality of the second period sample was similar to that in the first period sample (65% vs. 70% respectively). However, the authors report a significant reduction in mortality between the two period samples for patients with initial blood pressure readings < 60 mmHg from 87.7% prior to ALS implementation to 50% post-ALS implementation ($p = 0.025$). Based on these later results the authors suggest that ALS reduced mortality in patients with severe penetrating abdominal injuries.

Data presented in the article, however, contradict this finding. First, the overall mortality was reduced by only 5% which was not statistically significant and second, the mortality for patients with initial blood pressure ≥ 60 mmHg increased from 9.3% prior to ALS to 11.5% post-ALS. In addition, the mean overall response and scene times increased from 22 minutes and 11 minutes respectively for the pre-ALS period, to 38 minutes and 21 minutes respectively during the ALS period. These differences were not tested for statistical significance. The significant α level of 0.025 in the mortality rate difference for patients with initial BP < 60 mmHg was achieved following at least two pairwise comparisons using the same group while not controlling for the number of tests performed. Finally, although significant differences between the two groups were demonstrated with respect to mechanism of injury, this variable or any others were not controlled for in the analyses.

A study reported by Jacobs et al. from Boston in 1984 (Jacobs et al.,1984), indicated that the Trauma Score (TS) of 80 critically injured patients treated by an ALS crew at the scene improved significantly while en-route to the hospital, whereas no such improvement was noted in 98 similar patients who were treated by a Basic Life Support (BLS) crew. The authors then showed that improvement in TS was significantly correlated with survival. However, in a multivariate logistic regression with survival as the outcome, and controlling for scene time, original TS, and change in TS, the type of treatment (ALS vs BLS) was not significantly associated with survival. The only real conclusion from this study is that of the potential impact of ALS on improving the TS while en-route to the hospital. Given the dynamic and unstable nature of this and any other physiological severity index, these findings have minimal significance.

In a study reported in 1988 by Potter et al., the outcome of 472 trauma patients in Sydney, Australia was compared to the outcome of 589 similar patients from Brisbane (Potter et al.,1988). The data were collected during two different four-month periods in 1984 when on-site ALS was available in Sydney and only BLS on-site care was available in Brisbane. The authors also analyzed separately 96 severely injured patients (ISS $\geq$ 25 or AIS $\geq$ 4) treated in Sydney by ALS and 74 similar patients from the Brisbane sample.

The difference in the overall mortality in the severely injured patients (35% (33/96) for the ALS and 41% (30/74) for the BLS group was not significant ($p = 0.26$). The authors then reported that the proportion of deaths occurring before 24 hours was significantly lower for the ALS group (46%) compared to that in the BLS group (73%). Based on this finding, the authors concluded that ALS provided in the Sydney sample significantly reduced mortality when compared to the Brisbane patients who received BLS only. When multivariate analysis, controlling for injury severity (ISS), age, sex, and time to definitive care was used to predict survival , ALS was not significantly associated with decreased mortality.

The significantly lower proportion of early mortality in the Sydney sample may be partially explained by the shorter time to definitive care (mean 59 ± 57.5 minutes) as compared to Brisbane (90 ± 72.6 minutes). Three fatalities for which no vital signs were detected at the scene were excluded from the Sydney sample although no such exclusions were noted for the Brisbane sample. If these three cases were to be added to the analyses, the differences in proportion of early deaths between the two samples is non-significant ($p = 0.050$). Furthermore, the significant difference with respect to 24-hour mortality was found only after performing eight pairwise comparisons for different survival time intervals from 0 minutes to 14 days, without

using survival or life table analysis, or controlling for the number of comparisons. Therefore, the results of this study are inconclusive and the data as presented fail to support the authors' conclusions.

Using an index of mortality adjusted for the number of miles travelled, Alexander et al. demonstrated that the motor vehicle accident related mortality was significantly lower for counties in Florida with ALS systems when compared to counties with only BLS systems (Alexander et al.,1984). In this study, the counties with level I trauma centres had the lowest overall rates and significantly lower mile adjusted mortality rates when compared to counties without trauma centres. The authors conclude that ALS systems with trauma centres resulted in lower motor vehicle accident mortality. However, the independent impact of ALS on mortality was not demonstrated.

In 1988, Reines (Reines et al.,1988) reported data from the South Carolina Highway Trauma project, showing that an increase in blood pressure occurred en-route to the hospital in 32% of 435 trauma victims of motor vehicle accidents receiving ALS on-scene compared to 12% of 102 victims receiving only BLS ($p < 0.05$). In this study, a review panel considered on-site ALS appropriate in 85% of the cases, and harmful in only 2% of the cases receiving such care. The authors hence concluded that ALS was appropriate and beneficial for the treatment of MVA related trauma.

This study failed to demonstrate any impact of ALS other than an acute increase in blood pressure. The effect of ALS on survival was not tested and the statement regarding "appropriateness" of ALS is of limited importance.

A series of three studies from Denver which support the use of ALS systems has been reported. In the first study, Pons (Pons et al.,1985) presented data on 203 patients with critical penetrating thoracic or abdominal wounds and showed that on-scene ALS did not increase time to definitive care, while the blood pressure increased en-route to the hospital in 54% of these patients. The overall survival in this sample was 82%. The authors contend that this was attributable to the advanced life support provided at the scene and resulted from initially improving the hemodynamic status of the patients.

In the second study of the series, Cwinn et al. (1987) studied 114 blunt trauma victims from the same population studied by Pons. Of these 114 patients, 74 (65%) survived. There were 87 patients among these 114 with vital signs detectable at arrival of the ambulance, and 84% of these survived. The authors present data which show that scene time did not increase significantly by increasing the number of ALS procedures performed. Based on these results, the authors concluded that the use of ALS resulted in the high survival rates and did not significantly increase the time interval between injury and arrival at the hospital.

In the final study from this series, Honigman reported data on 70 patients with penetrating heart injuries (Honigman et al.,1990). In this sample, 30% survived in spite of a low mean TS and the fact that 79% of the patients had an on-site TS < 6 with 61% of these having an on-site TS = 0. The authors report that performing more on-site procedures improved survival in this patient group and did not significantly increase scene time.

The overall conclusion derived from these studies is that in the Denver system the number of ALS procedures performed at the scene does not significantly increase scene time, and some patients may experience acute hemodynamic improvement as a result of these on-site stabilization procedures. However, the independent beneficial impact of ALS on survival was not demonstrated, especially in that all patients were treated at a level I regional trauma centre which undoubtedly contributed to any improved outcome. Furthermore, all three of these studies lacked a control group.

2.2.1.1.2. Summary

The studies reviewed in this section fail to provide conclusive evidence of any beneficial effect of on-site ALS for the pre-hospital management of trauma. Several of these studies lacked a control group in the evaluation of ALS (Hedges et al.,1982; Pons et al.,1985; Cwinn et al.,1987;

Honigman et al.,1990). Two studies comparing ALS versus BLS used indirect theoretical associations of other parameters with survival to demonstrate the benefit of ALS. Specifically, Reines et al. (1988) used change in blood pressure and Jacobs et al. (1984) used change in TS en-route from the scene to the hospital. Neither of these studies demonstrated an effect of ALS on trauma-related mortality.

In another study using a different indirect association to support the use of ALS in the pre-hospital management of trauma, Ornato reported significant negative correlations between the annual number of EMTs trained in Nebraska with trauma-related mortality. The data from this study are purely correlational and do not warrant further consideration (Ornato et al.,1985).

Aprahamian et al. (1983) and Potter et al. (1988) used mortality reduction as an outcome in comparing trauma patients treated with ALS and BLS. However, both of these studies failed to show an association between ALS and a decrease in overall trauma-related mortality. Aprahamian demonstrated a significant decrease in mortality for critically injured patients (initial BP < 60 mmHg) receiving ALS on scene as compared to patients receiving only BLS, however, the converse was true for non-critically injured (initial BP ≥ 60 mmHg) patients. Although Potter demonstrated a marginally significant decrease in 24-hour mortality in patients treated with on-site ALS, overall mortality was not significantly reduced.

2.2.1.2. "Scoop and Run"

2.2.1.2.1. Review of the Studies

This section reviews studies opposing the use of ALS at the scene for severely injured patients. The studies reviewed in this section are summarized in Table 2.7.

In one of the earlier studies testing the effectiveness of on-site ALS in trauma, Gervin et al. (1982) presented data from 13 patients with penetrating heart wounds treated at a level I trauma centre in Tuscon. Of the 13 patients in the study, six were taken directly to the hospital by a BLS unit without attempts for on-site resuscitation, and seven were treated by an ALS unit implementing endotracheal intubation, I.V. infusion, and cardiac massage. All six of the BLS treated patients arrived at the hospital within nine minutes from the time of the injury whereas more than 25 minutes elapsed prior to arrival at the hospital for all ALS treated patients. There were 5 (83%) short-term and 4 (67%) overall survivors among the BLS treated patients. None of the ALS treated patients survived. The authors conclude that the increased on-scene time contributed to the 100% mortality in the ALS group and that prompt transport to the trauma centre contributed to the better outcome in the patients treated by BLS.

In this study, the comparability of the two patient groups with respect to injury severity and other prognostic factors was not demonstrated. The number of patients used

was extremely small and the method of allocating patients to treatment regimens was not explained. Nonetheless, the important finding is that of the increased delay to definitive care observed in the ALS group, and the difference in mortality is noteworthy.

Similar conclusions were drawn in a study done by Ivatury et al. (1987) on the outcome of 100 patients with penetrating thoracic injuries who were treated at a level I trauma centre in Bronx, New York. On-scene ALS was attempted on 51 of these 100 patients while 49 were transported directly to the hospital. The overall survival was higher for the BLS patients (9/49: 18%) as compared to the ALS patients (1/51: 2%), ($p = 0.06$). These results remained unchanged when the data were analyzed separately for different prognostic categories. An interesting observation from these data is that although the mean on-scene time for the ALS patients was 12.2 minutes compared to 3.0 minutes for the BLS patients, the proportion of patients with improved /unchanged /deteriorating physiological status en-route was similar for the two patients groups. The authors also noted that a higher proportion of patients in the BLS group arrived at the hospital with detectable vital signs compared to the ALS patients. Furthermore, the authors demonstrated that the two groups were comparable with respect to injury severity and type of injury.

Based on these findings, the authors concluded that ALS at the scene increased the delay to definitive care and consequently increased the mortality in the patients with penetrating cardiac injury. Although the method of allocating patients to treatment groups was not described, the authors demonstrated that the two groups were similar with respect to injury severity and type.

In a similar study, Cayten (1984), showed that in 65 trauma victims treated by BLS only at the scene, there were three deaths expected according to their injury severity, and three deaths occurred. In contrast, for the group of 37 patients in this study who received ALS at the scene, while only four deaths were expected, seven deaths were observed. In this study, the mean scene time for the BLS patients was 17 minutes compared to 25 minutes for the ALS patients. The authors conclude that ALS was not effective in reducing mortality, and attributed the excess mortality in the ALS treated patients to the increased scene time. The number of deaths in this study is small and the method of determining expected deaths may influence the outcome. However, there is no reason to believe that this effect will systematically favour the BLS group. It is also important to note that approximately eight minutes more were spent on the scene by the ALS units without necessarily demonstrating an improvement in outcome.

Increased on-scene times associated with on-site ALS were reported by Tsai et al. (1987) in a study on 3184 emergency pediatric cases, 1192 of which were severe trauma-related. In this study, the authors showed that the on-scene time increased significantly from a mean (± 1 s.d.) of 16.0 ± 10.7 minutes for a simple evaluation, to 25.5 ± 16.0 minutes for complex advanced life support. The mean scene time was 10 minutes longer for patients who had I.V. lines initiated at the scene. There were 23 trauma-related cardiac arrests in this sample, none of which survived. The authors conclude that ALS was ineffective in resuscitating these patients and that it increased scene time inappropriately. The lack of a control group in this study as well as incomplete data on injury severity and overall mortality hinder any definitive conclusions. Nevertheless, the increase in scene time and failure to revive all of the 23 arrested cases associated with ALS are noteworthy observations.

The over utilization and inappropriateness of ALS in the pre-hospital management of trauma was demonstrated by Luterman from Alabama in a study published in 1983 (Luterman et al.,1983). This study reported data on 919 trauma victims who were treated by EMT-P (Advanced-EMT) paramedics at the scene and who were subsequently transferred to a level I or II trauma centre. For 318 of these patients, a panel of experts assessed that a paramedic was not required

and only a basic EMT was sufficient. However, 226 (71%) of these patients received ALS at the scene. ALS was also used for 31 (41%) of the 74 patients for whom the panel concluded that no EMT at all was required. In this study, for the majority of the major trauma cases, the scene time exceeded the time required to transport the patients to a trauma centre by more than 10 minutes. The results from this study showed that on-site ALS is over-used and that this method of pre-hospital care is not appropriate when transport time to a medical facility is relatively short, as is the case for most urban settings.

In another study evaluating the impact of ALS, specifically the use of I.V. infusion, Smith et al. (Smith et al.,1985) demonstrated that this procedure did not improve the physiological status of patients with penetrating injuries. The TS did not improve significantly from the scene to the hospital in the 52 patients in the study. The use of I.V. infusion required an additional scene time of 12 minutes. The authors stated that five of the 14 deaths in this sample may have been prevented if the patients were transported directly to the hospital. The failure of I.V. infusion to improve the TS contradicts the conclusions of Jacobs et al. (1984) who reported a significant increase in TS associated with the use of on-scene ALS. In addition, the long time required to initiate an I.V. in this study further supports the argument that the

"Scoop and Run" policy is most appropriate for pre-hospital management of patients with penetrating trauma.

2.2.1.2.2. Summary

In summarizing the results from these studies (Table 2.7), the general conclusion is that ALS increases the time to definitive in-hospital care without providing a demonstrable benefit to trauma victims. The studies by Gervin et al. (1982), Ivatury et al. (1987) and Cayten et al. (1984) compared trauma patients receiving pre-hospital ALS care with patients receiving only BLS care. All three of these studies reported significantly longer delays to hospitalization in the group of patients receiving ALS care compared to those receiving BLS. In addition, the results from these studies showed significantly worse outcomes in the ALS treated patient groups in spite of the increased time spent on the scene and the use of advanced stabilization procedures. The studies by Smith et al. (1985), and Tsai et al. (1987) further supported the belief that ALS increases scene time without producing a beneficial change in physiological status (Smith et al.,1985) or reduction in mortality (Tsai et al.,1987). Neither of these two studies used a control group and, the relative impact of ALS as compared to the use of BLS on trauma outcome cannot be assessed. The lack of improvement in TS reported by Smith and the 100% failure in resuscitation reported by Tsai

are, however, important findings. Finally, the data reported by Luterman et al. (1983) show that ALS is used more frequently than is necessary and provide a strong argument against the use of ALS in situations where prompt transport to a trauma centre or an appropriate hospital is possible.

Although the data in these studies better support the conclusions of the authors than the data presented by the proponents of ALS, it must be noted that these data were also obtained from relatively small samples, especially the study by Gervin et al. (N = 13) (1982). In addition, two of these studies (Gervin et al.,1982; Ivatury et al.,1987) focused on penetrating injuries only and the studies by Tsai and Smith did not use comparison groups. Nevertheless, the consistent finding that ALS increases time to definitive care without providing any benefits, as well as the failure of the data presented by the ALS supporters to demonstrate a true positive impact on the outcome of trauma, have shifted the scale in favour of the "Scoop and Run" position.

2.2.1.3 On-site ALS Procedures.

The studies reviewed in the previous sections focused primarily on the evaluation of ALS as a whole, without focusing on specific on-site maneuvers. Extrication, spinal immobilization, bandaging, and dressing of wounds are basic procedures which are necessary to facilitate access to the

patient and preparation for transport. In addition, other simple procedures such as nasal administration of oxygen and splinting of fractures are procedures which are easily and quickly performed and are beneficial in avoiding further deterioration or damage.

The controversy with respect to on-site ALS in trauma pertains to the on-site use of invasive or advanced life support interventions, specifically the initiation of intravenous lines, intubation using either endotracheal intubator or esophageal obturator, and the application of pneumatic anti-shock garments (PASG). These procedures may require increased scene time and extensive training of paramedics at the EMT-P level (100 hours and 6 months experience). The controversy is whether these procedures increase scene time and therefore the time to definitive care, thus increasing risk of mortality without providing any benefit, or do they actually contribute to the stabilization of critically injured patients and decelerate physiological deterioration while en route to the hospital.

The literature on research addressing the overall effectiveness of specific on-site maneuvers in improving trauma outcome is scarce. Randomized controlled trials have been reported only for the PASG. Several studies contrasting different methods of airway management have been published, but none that evaluate the impact of intubation in general on the outcome of trauma. Finally, with respect

to I.V. infusion, several studies have been reported which evaluate the success rates of intubation or the time required to initiate an I.V. at the scene. The study by Smith et al. (1985) reviewed in the previous section focused on I.V. infusion. The purpose of the study, however, was to assess ALS in general.

In the following section, studies focusing on these three ALS procedures namely PASG, I.V. initiation, and intubation will be reviewed.

2.2.1.3.1. Pneumatic Anti-Shock Garments (PASG).

The PASG consists of three independently inflatable compartments: two for the legs and one for the lower abdomen. The theory behind the use of this device is that the increased external pressure in the lower part of the body will shunt blood to the upper and central body regions, and will maintain hemodynamic balance in the vital organs. The PASG acts through the arterial pressure by increasing the resistance and lowering the blood flow in the lower body. This device was recommended for use in patients in haemorrhagic shock or with decreased blood volume (MacKersie et al.,1984; McSwain,1988).

In 1984, MacKersie (MacKersie et al.,1984) reported a retrospective study comparing the outcomes of two similar groups of patients, one consisting of 60 patients who received PASG treatment, and a control group of 101 patients

not receiving PASG treatment. The final analysis focused on 47 patients in the PASG and 50 in the no-PASG groups. The authors found that although blood pressure of the PASG patients improved significantly from the scene to the hospital, the overall mortality was similar for the two groups (49% PASG, 54% no-PASG). The authors also report a non-significant increase with respect to mean time spent on scene, associated with PASG application (PASG: 13.1 ± 6.2 minutes, no-PASG: 12.1 ± 6.9 minutes).

A series of articles has been published on data from a prospective randomized controlled trial of the PASG which was initiated in Houston in 1983. In this study, trauma victims were randomized to either receive or not receive the PASG using an alternative day schedule. Thus on every other day the ambulances were not equipped with the PASG. The control group received the same ALS treatment as the study group and all patients were transported to Ben Taub General Hospital, a regional trauma centre facility. In this study, the unit of randomization was the day not the patient, therefore not all patients in the PASG days were treated by this procedure but the apparatus was available. The results of these studies are summarized in table 2.8.

The first article of this series was reported by Bickell et al. (1985). In this study, 32 trauma patients were randomized to the non-PASG group and 36 to the PASG group. The two groups were comparable with respect to

demographic variables as well as on-scene measurement of Trauma Score (TS) and Blood Pressure. The outcome examined was the change in TS from the scene to the arrival at the hospital. The results of this study failed to show a significantly higher improvement in TS for the PASG group (0.7 ± 1.5) as compared to the non-PASG group (0.6 ± 1.7), ($p > 0.10$).

Using a larger sample of patients from the same study in 1986, Mattox et al. (1986) compared 160 patients for whom the PASG was used and 182 patients for which the PASG was not available. The two groups were statistically non-different with respect to type of injury, initial field Trauma Score, response, scene and transport times, pre-hospital I.V. fluid infused, ISS, and probability of survival as determined by the TRISS method.

The results of this study showed no significant differences between the two groups with respect to mortality, (PASG: 49/160 (31%), No-PASG: 40/182 (22%)), mean emergency room Trauma Scores (PASG: 11.4 ± 5.9, No-PASG: 11.5 ± 5.3), or mean length of hospitalization (PASG: 10.7 days, No-PASG; 8.8 days), mean duration of intensive care unit stay (PASG: 3.7 days, No-PASG: 3.9 days).

The authors, however, reported several problems or complications associated with the use of the PASG equipment, including difficulty in gaining access to the patient in order to perform evaluation or treatment. Anterior tibial

compartment syndrome requiring fasciotomy occurred in three patients due to prolonged use of the PASG. Amputation above the knee was required for one of these patients. Another patient experienced diaphragmatic herniation of the abdominal organs into the thorax.

In 1987, Bickell published another article from the same study (Bickell et al.,1987). In this study, 97 patients with penetrating abdominal injury were randomized to the PASG group and 104 were randomized to the no-PASG group. The groups were similar with respect to age, mechanism of injury (gunshot, stabbing), Trauma Score at scene, ISS, survival probability by the TRISS method, anatomical site of injury, response time, transport time, and volume of crystalloid infused at the scene. The only significant difference detected was with respect to the scene time (no-PASG: 13.1 ± 7.9 minutes, PASG: 17.3 ± 8.3 minutes, $p < 0.001$). There were no significant differences between the PASG and control groups with respect to survival (PASG: 67/97 (69%), no-PASG: 81/104 (78%), or survival time. Furthermore, the no-PASG group had a non-significantly higher survival rate and an increase in the mean survival time as compared to the PASG group.

The general conclusion from the Houston study is that no beneficial effect of the PASG in the treatment of hypotonic trauma victims was demonstrated either in the short-term physiological status, or in the overall survival.

In a summary of the findings from this study, Pepe points out that the majority of the patients had penetrating injuries and that additional studies may be required to further evaluate the PASG in blunt trauma (Pepe et al.,1986). This author further points out that the setting of the trial was in an urban location with a well developed EMS system and well trained paramedics experienced in penetrating trauma, functioning under the strict supervision of a physician. Finally, the patients in this study were all treated in a level I university-affiliated trauma centre. These results therefore indicate that the PASG does not provide additional benefit in a well organized urban EMS with adequate trauma centre facilities. In this review, however, Pepe does not take into account the negative results of applying the PASG.

The reports or complications associated with the use of the PASG are noteworthy and should be considered in view of the lack of evidence of a beneficial effect of this procedure. Based on such results, the use of the PASG has been terminated in the Houston Emergency Medical System (Mattox,1989). The use of the PASG has not been defended, at least for urban settings, and the risk of complications have recently seriously shifted scientific opinion against this apparatus (Mattox,1989; Lloyd,1987).

2.2.1.3.2. Intravenous fluid replacement.

The rationale for the use of out-of-hospital intravenous fluid replacement (I.V.) is that this procedure will control the deterioration of the hemodynamic status of the haemorrhaging patient by compensating for the blood loss. Opponents of the use of I.V. lines at the scene of the accident present increased field time, low success rates, and inability to adequately replace the blood volume lost, as well as potential complications or adverse effects, as arguments against the use of the procedure (Trunkey, 1983; 1984; Gold et al.,1984; Smith et al.,1985).

Supporters of on-field I.V. infusion argue that successful establishment of I.V.s by well trained paramedics requires less than a few minutes of scene time and that the deterioration due to blood loss is augmented although the volume may not be totally replaced (Jacobs et al.,1984; Pons et al.,1985; Cwinn et al.,1987; Honigman et al.,1990; Reines et al.,1988). However, there are a few studies which specifically evaluate the impact of on-scene I.V. fluid replacement on the outcome of trauma.

Copass reported a retrospective study from Seattle on 131 patients suffering a cardiac arrest following critical injury (Copass et al.,1984). In this study, a significantly higher proportion of the survivors (30/30 or 100%) had on-site intravenous fluid replacements compared to 70% (70/101) of the non-survivors ($p < 0.01$). The authors do not provide

information on the reason for which I.V. lines were or were not used, and the analyses did not control for parameters associated with the need for I.V. infusion, such as injury severity, penetrating trauma, or other potential confounders.

In another study published in 1985, Aprahamian reported data on 95 trauma victims without detectable vital signs at the time of arrival of the ambulance. According to protocol, I.V.s and intubation were attempted on all patients. However, I.V. establishment was successful in 74% (N = 70). The mean on-scene time for patients with successful and non-successful I.V. placement was identical (22 minutes). For patients with unsuccessful attempts at both I.V. and intubation, the mean scene time was 14 minutes. The difference lacked statistical significance, probably due to the small numbers of subjects. The authors state that 3.2% of these patients were resuscitated as a result of these ALS procedures.

The main argument against the attempt at establishing intravenous lines at the scene of the accident is the time required for this procedure. Trunkey et al. (1983) and others (Smith et al.,1985; Gold et al.,1984; Bodai et al.,1987; Border et al.,1983) have argued that by the time that an I.V. line is established a patient who is bleeding at a moderate or high rate may loose up to 30 to 50 ml/min. According to these authors, the maximum volume of blood

replaced within 10 to 20 minutes is 1000-2000 ml. Since only 25% (Smith et al.,1984) to one third (Trunkey,1983) of the volume infused (i.e. 250 to 700 mls) will remain in the system, the amount of fluid replaced is considerably less than the blood lost.

Several authors have reported data on the estimated time required to establish an I.V.. The majority of these studies which are summarized in table 2.9 are retrospective, and it is generally difficult to separate the time required to perform a specific procedure from the total scene time. Cwinn et al. (1987) has prospectively measured the time required to establish an I.V. in 16 patients with blunt trauma. These results showed that a mean time (± SEM) of 2.98 minutes (± 0.37) was required to establish an I.V. and that in these 16 patients the mean (± SEM) scene time was 12.6 minutes (± 1.41). Smith et al. (1985) has also reported data on the time required to establish an I.V. in 52 severely injured patients, the majority of which had penetrating injuries. In this sample the mean time to initiate an I.V. was 8.6 minutes for 9 patients with no blood pressure at the scene, 12.6 minutes for 15 patients with on-scene blood pressure below 70 mmHg, and 11.5 minutes for 28 patients for which the scene blood pressure was between 70 mmHg and 100 mmHg. The mean total scene time was 16.2, 17.3 and 14.5 minutes for these patient groups respectively.

The mean time required to initiate an I.V. reported by Smith is considerably longer than that reported by Cwinn et al. However, the patients in Smith's study had penetrating injuries, were haemorrhaging, and I.V. initiation was therefore made more difficult. Several other authors have reported data on the time required to initiate an I.V.. Some of these studies are summarized in Table 2.8.

The three prospective studies which reported considerably shorter times used data from medical and trauma cases, the majority of which were of blunt injuries (Cwinn et al.,1987; Jones et al.,1985; Pons et al.,1984). The other studies either focused on penetrating injuries (Smith et al.,1985; Pons et al.,1984; Honigman et al.,1990) or a combination of penetrating and blunt trauma (Aprahamian et al.,1985; Reines et al.,1988). Consequently, comparing the results from these studies is difficult.

The studies reviewed assessing the use of pre-hospital I.V. in trauma patients have failed to demonstrate a benefit associated with this procedure. The time required to initiate an I.V. varies from study to study and appears to depend on the method of estimating this interval and the type of patients used. However, even the studies reporting short times have not demonstrated a beneficial impact of on-scene intravenous infusion. Finally, computer simulation studies have demonstrated a significant beneficial effect of I.V. infusion on computer patient survival for bleeding

rates of 25 ml/min and long transport times (> 20 min) (Wears et al.,1990). Such benefits have not been demonstrated in real-life patients.

2.2.1.3.3. Intubation

The rationale behind the use of on-scene intubation for severely injured patients is that this procedure will maintain adequate lung inflation and consequently sustain adequate rates of cellular respiration, thus preventing shock in tissues, specifically those of the brain and heart (Pepe et al.,1985). There is considerable agreement amongst researchers in the area of trauma care that management of the airway in severely injured patients should be initiated at the scene of the accident (Bodai et al.,1987; Pepe et al.,1985; Trunkey,1984). Evaluative research in the area has focused on the comparison of various methods of intubation with the majority of the researchers supporting the use of the endotracheal intubation over the esophageal obturator (Gold et al.,1984; Trunkey,1984; Bodai,1987; Pepe et al.,1985). Several studies have been published either on the evaluation of the two methods or focusing on one method's rate of successful application in the field (Jacobs et al.,1983; Stewart et al.,1984). Nevertheless, no studies have specifically addressed the question of whether intubation of any method is actually beneficial in the pre-hospital management of trauma victims (Gold et al.,1984).

As was the case with I.V. lines, several studies have been reported in which intubation was mentioned as one of the on-site procedures performed for the management of trauma victims (Honigman et al.,1990; Jacobs et al.,1984; Pons et al.,1985; Aprahamian et al.,1986). With the exception of one study by Copass, no other studies have been reported in which an attempt has been made to estimate the independent impact of intubation on survival from trauma. Copass reported that in a sample of 131 critically injured patients requiring cardiopulmonary resuscitation, 97% (29/30) of the surviving patients compared to 65% (66/101) of the non-surviving patients had an endotracheal intubation applied at the scene ($p < 0.01$). However, as was mentioned in the previous section, in this study there was no control in the analysis for type of injury (blunt vs penetrating) or injury severity.

2.2.1.4. Physicians at the Scene

2.2.1.4.1. Aeromedical Care

In certain communities in the USA, physicians are part of an aeromedical system and are transported by helicopter to the scene of the accident where they provide care to severely injured or critically ill patients. In some instances, these physicians are also assisted by nurses. Supporters of these systems propose that the time between injury and definitive or semi-definitive care is shortened

by transporting the physician to the scene of the accident (Carraway et al.,1984; Fischer et al.,1984; Valenzuela et al., 1990; Schwab et al.,1985). Theoretically, a physician should be better able to assess the particular needs of a patient and reach decisions about the appropriate care without requiring direction. Thus, on-site physician systems are free of the short-comings that could be associated with insufficient training of EMTs or lack of adequate communication between the on-scene crew and the supervising physician. In fact, such systems may theoretically represent the optimum level of on-scene ALS.

In 1983, Baxt reported a study comparing 150 patients of blunt injuries who were transported to a trauma centre via a standard land ambulance with 150 patients transported by a helicopter staffed with a physician and a nurse (Baxt et al.,1983). The two groups were similar with respect to injury severity and demographic parameters. However, a significantly higher proportion of patients in the aeromedical group were injured in a rural setting ($p < 0.001$). The authors noted that although the mortality rates between the two groups were not different, a significant difference with respect to observed to expected death ratios between the aeromedically transported patients and the land transported patients was detected ($p < 0.001$). The authors concluded that the aeromedical system reduced mortality.

Data presented in this article showed that the time to initial physician contact was almost identical for the two groups (land: 35 minutes, aeromedical: 34 minutes). Earlier contact with a physician could not therefore explain the better outcome in the aeromedical group. The lack of difference in the overall mortality is the most reliable finding of this study, given the comparability of the two treatment groups.

Using the same design and setting, Baxt et al., (1987) suggested that the injury severity (GCS) adjusted mortality in 104 aeromedically transported patients with severe head injuries was significantly lower than that observed in 128 similar patients transported by a land ambulance ($p < 0.001$). This difference was observed in spite of the longer pre-hospital time for the aeromedical group, (minutes); land:23, aeromedical:57). However, the overall mortality was not statistically significantly different (land: 40%, aeromedical:31%). In fact, on close examination of the data, it is evident that the proportion of patients dying was lower for the aeromedical group only for the group of patients with GCS scores of 3,4 and 8 and the converse is true for patients with GCS of 5,6 and 7. Moreover, an analysis of the data in the article with the Mantel-Haenzel methods did not confirm the results of the author. The results of this study are therefore neither reliable nor do they show a beneficial impact of aeromedical transport of

trauma patients.

Contrary to the results reported by Baxt in these two studies, Schiller reported a significantly higher mortality in patients transported via helicopter (Schiller et al.,1988). This study focused on patients with ISS scores between 20-39, thus defining patient population with critical survivable injuries. The percent mortality for the 347 patients transported by a helicopter was 18% compared to 13% for the 259 patients transported via land ambulance ($p < 0.05$). The mean time between injury and arrival at the hospital for patients injured in urban areas was significantly longer for the helicopter transported patients (53 ± 4 minutes) compared to the land transported patients (37 ± 6 minutes), ($p < 0.005$). The data suggest that the increased mortality in the aeromedically transported patients group may be due to the increased delays to definitive care.

The results from these studies suggest that aeromedical systems which transport a physician to the site of the accident and the patient to the trauma centre may have some benefit in rural locations where hospitals are considerable distances away. However, such systems are not likely to prove beneficial in urban settings with well established EMS systems incorporating efficient ground transport, communications, and advanced in-hospital trauma care facilities.

The studies reviewed have failed to prove that aeromedical transport reduced time to definitive care, hence, the main purpose of using these programs is defeated. These data also show that the use of on-flight physicians does not introduce benefits over and above the use of land ambulance and direct transport to a trauma centre. This is particularly true for urban settings.

2.2.1.4.2. Physicians in Ground Ambulances

In the United Kingdom (Silverston et al.,1985), Sweden (Ottonson et al.,1984), France (Hervé et al.,1986; 1987), Germany (Oestern,1985), and Jerusalem (Applebaum,1984), physicians may be dispatched either by ground transport ambulance or helicopter to the scene of the accident. Evaluation of such systems is essential as they theoretically represent an optimum level of pre-hospital care. However, studies addressing this issue are rare.

In Sweden, emergency trauma care is not regionalized and ambulances staffed (when necessary) with a physician will transport the patient to the nearest hospital. In a study by Ottonson evaluating this system, 1 (1%) of the 102 fatalities occurring before arrival at the hospital were considered as preventable and 2 (2%) were considered as potentially preventable (Ottonson et al.,1984). Of the 24 deaths occurring after arrival at the hospital and within 24 hours from the time of the injury, 3 (12%) were considered as potentially preventable and none were considered as

preventable. There were 32 deaths which occurred more than 24 hours after the time of the injury. Two (6%) of these were caused by inadequate care due to a missed diagnosis and 30 (94%) died despite adequate care. According to the authors, the low preventable death rate indicates effectiveness in reducing mortality. However, the definition of preventable deaths as well as data regarding the overall injury severity of this sample, and the differences between deaths classified as preventable or non-preventable, were not reported. In addition, the lack of a control group does not allow adequate assessment of the impact of the system on trauma mortality.

Another study reported in 1987 by Hervé from Creteil, France, compared a series of 81 patients with multiple injuries treated at the surgical intensive care unit during 1969 to a second series of 86 similar patients treated at the same centre during 1979 (Hervé,1985). Pre-hospital care by a physician, a nurse, and an ambulance attendant was provided to the second series of patients.

The results of this study showed that the 24-hour mortality was significantly lower in the second series, but, overall mortality was not significantly different. The authors suggest that patients in the second series who would otherwise die were still alive at arrival at the hospital, thus increasing their probability of survival. However, this statement is contradicted by the lack of a difference in overall mortality.

The results from these studies failed to demonstrate a beneficial impact of on-site ALS performed by physicians on the outcome of trauma. As these were not controlled evaluations of the use of on-site ALS by physicians, the contribution of these data is rather limited.

2.3. SUMMARY

The literature which was reviewed in this chapter leads to the following conclusions regarding the knowledge on emergency trauma care. First, the importance of time in treating severe injuries had been recognized from antiquity to the present day. The experiences from military conflicts as well as studies evaluating trauma care systems have shown that the "golden hour" principle of providing definitive medical care to severely injured patients within 60 minutes is the most important factor in preventing trauma mortality.

The other important factor in preventing trauma mortality is the quality of in-hospital care. Studies evaluating trauma care systems have shown that patients treated at organized regional trauma centres have a higher probability of surviving when compared to similarly injured patients who are cared for in non-specialized facilities.

The evidence in the literature has further shown that the presence of rapid patient transport systems and trauma centres functioning independently of each other are less effective in preventing trauma-related deaths. The integration of the pre-hospital and in-hospital components into a single system incorporating efficient communication and coordination methods is essential for effective management of trauma. Evaluative research in the area has shown that integrated trauma care systems demonstrate increased efficiency in reducing trauma mortality compared

to systems without adequate integration and organization of pre-hospital and in-hospital emergency medical components.

The main controversy in the area of trauma care is with respect to the nature of pre-hospital care. Specifically, whether on-site stabilization using advanced life support or whether basic life support with rapid transport is more beneficial to the severely injured patient. This is an on-going controversy which has generated considerable debate during the last several years. Supporters of pre-hospital advanced life support "Stay and Stabilize" argue that further deterioration is prevented by on-site stabilization. However, the studies presented by this side have failed to demonstrate that ALS is more beneficial than immediate transport. Studies presented by supporters of "Scoop and Run" have shown that ALS does not reduce the mortality risk in severely injured patients. In addition, several of these studies have demonstrated that on-site ALS increases delays to definitive hospital care and may consequently increase the risk of dying. The evidence from studies on the PASG, I.V. or intubation, have failed to demonstrate or adequately address whether any of these procedures are effective in improving the outcome of trauma victims. The collective data from studies evaluating on-site physicians, either as members of an aeromedical unit or mobile intensive care unit, have failed to demonstrate that this method of pre-hospital care provides significant advantages over the use of BLS with immediate transport to a trauma care.

The accumulation of evidence has therefore shifted the weight of the proof towards the "Scoop and Run" side. This is primarily because of the lack of convincing evidence suggesting that ALS is effective. Furthermore, evidence suggesting that the use of on-site ALS procedures may increase the risk of dying by unnecessarily delaying definitive hospital care actually support the minimization of on-site care.

Several researchers agree with this impression (Hedges et al.,1988; Trunkey,1983;1984; Cales,1988; Gold,1987; Bodai et al.,1987; Border et al.,1982). Others have argued against a single solution or simplistic approach to the controversy around pre-hospital trauma care. These authors imply that "Scoop and Run" may be appropriate for certain injuries whereas "Stay and Stabilize" may be the method of choice of other types for injuries (Brill et al.,1981; Pepe et al.,1987).

In considering the evidence from these studies, it must be kept in mind that with the exception of the Houston study which evaluated the PASG apparatus, no other study was a randomized controlled evaluation of ALS in general, or of any specific on-site procedures. The majority of the studies were observational, utilizing existing variations in the available emergency medical care of trauma patients.

Several of these studies used preventable deaths as an outcome measure, which carries methodological problems

discussed in the previous chapters. The lack of an appropriate control group is often a design problem with observational studies which must be dealt with in the analyses. Unfortunately, a number of studies in this area either lack a control group or when a control group is used, there is often inadequate adjustment for the differences between treatment groups.

Results from these studies are consequently suggestive but non-conclusive and better designed prospective evaluations are necessary. Although the execution of randomized controlled trials for the evaluation of pre-hospital trauma care is not generally feasible, there is need for alternatively designed controlled evaluation in order to resolve the existing controversies. Studies should utilize statistical methods to compensate for design deficiencies. Large samples, possibly through multi-centre cooperation, should used in such studies to ensure adequate power.

Table 2 1 Mortality Rates and Delays to Medical Care During Recent Military Conflicts.

Conflict	Delay to care (hrs)	Injury Mortality Rate
WWI	12-18	8 5%
WWII	6-12	5 8%
Korea	2-4	2 4%
Vietnam	1	1 7%

Table 2 2 American College of Surgeons, classification of Trauma Care Hospitals (Boyd et al ,1983, Bresler)

ACS level	Trauma Care minimum requirements
I: (Regional Trauma Centre)	- 24 hr emergency services on-site * physicians * trauma surgeons * anesthesiologists * intensive care facilities * surgical nurses - other specialists available within 30 minutes on a 24 hr coverage
II· (Area wide Trauma Centre)	- 24 hr emergency physician - other services including surgeons 24 hr on-call or within 30 minutes
III Local	- no 24 hr coverage - medical and surgical services on-call only

Table 2 3 Classification of Emergency Medical Technician (EMT)

EMT-level	Training	Procedures performed
I (EMT-A)	80 hrs	- extrication - assess vital signs - initiate CPR - administer oxygen - bandage wounds - splint fractures - immobilize spine and neck
II (EMT-I) (Intermediate)	81-1000 hrs	- intubation - intravenous line establishment - PASG application * In addition to all procedures performed by EMT-A
III (EMT-P) (Paramedic)	> 1000 hrs 6 months training	- administer medications * In addition to all procedures performed by EMT-A and EMT-I

Abbreviation CPR = Cardiopulmonary Resuscitation
PASG = Pneumatic anti-shock garments

Table 2 4 Studies Supporting the Need for Improved Trauma Care

Author	Year	Sample	Study Sample	Source	Total Deaths	Preventable Deaths N(%)
Lowe et al	1983	MVA	659	Chart	135(26%)[1]	34(25%)
Ramenofsky et al	1984	Pediatric trauma deaths	100	Autopsy	100	53(53%)
Kreis et al	1986	non-CNS trauma deaths	246	Autopsy	246	52[2](21 1%)
Bolta et al	1986	MVA[4] trauma deaths	279	Autopsy	279	119[3](43%)
Campbell et al	1986	non-CNS trauma deaths	62	Autopsy	62	14(23%)
Dykes et al.	1989	pediatric MVA trauma deaths	367	Post-mortem reports	367	75(20%)

1 Excludes 143 deaths occurring before arrival of ambulance

2 In level I 12 1%, other 26 4%

3 52 of these had ISS ≤ 40

4 Only deaths occurring prior to admission were included

Abbreviations MVA Motor Vehicle Accident

CNS Central Nervous System

Table 2.5 Studies Evaluating Trauma Care Systems

Author	Type of Outcome	Patient Type	Comparison Method	Study Groups	N	Results: Outcome	Results: Authors' conclusions
West et al (1979)	Preventable Deaths	MVA deaths	Geography	RTC	non-CNS 16	1 (6%)	- Lack of adequate care in non-RTC region resulted in high preventable death rate
					CNS 76	2 (3%)	
				Non-RTC	non-CNS 30	22 (73%)	
					CNS 60	17 (28%)	
Cales (1984)	Preventable Deaths	MVA deaths	Before/ After	RTC	60	9 (15%)	- Improvement of care reduced preventable deaths
				Non-RTC	58	20 (34%)	
Klauber et al (1985)	Head Injury Death Rates (Population)	Trauma victims	Before/ After	PTS	-	19.4 - 17.5/ 100,000	- Decrease in time to definitive care decreased mortality due to head injuries
				Non-PTS	-	21.3 - 23.8/ 100,000	
Shackford et al.(1986)	Penetrating deaths Mortality rates	Trauma victims	Before/ After	RTC	1366	Mort:112 (8.2%) P.D. 11 (9.8%)	- Implementation of RTC reduced overall and preventable death rates
				Non-RTC	341	Mort. 90 (26.4%) P.D. 19 (21.6%)	
Shackford et al.(1987)	Observed/ Expected Survival	Trauma victims	-	RTC	198	Observed 29.1% Expected 18.1%	- Higher survival than expected by TRISS attributed to improved trauma care
Guss et al.(1989)	Preventable Deaths	Trauma deaths	Before/ After	RTC	211	2 (1%)	- Implementation of RTC decreased preventable death rate
				Non-RTC	177	20 (11.4%)	
Mullner et al (1977)	CFR	MVA	Before/ After	RTC	-	84.6	- Care in trauma centres reduced CFRs
				Non-RTC	-	114.9	

Abbreviations

MVA	Motor Vehicle Accidents
RTC	Regionalized Trauma Care
PTS	Patient Transport System
CNS	Central Nervous System
Mort	Mortality rate
P.D.	Preventable Death rate
TRISS	Trauma Injury Severity Score
CFR	Case Fatality rate

Table 2 6 Studies Supporting Advanced Trauma Life Support

Author	Type of Outcome	Patient Type	Comparison Method	Study Groups	N	Results: Outcome	Results: Authors' conclusions	Results: Comments
Hedges et al (1982)	Expected Mortality	Blunt Trauma	Expected/ Observed	NA	163	1 death/ 2-6 expected	- observed mortality lower than expected	- selection bias possible - low severity sample
Aprahamian et al (1983)	Mortality	Penetrating Abdominal	Before/ After	BLS ALS	64/21[1] 48/22[1]	70%/88%[1] 65%/50%[1]	- Reduced mortality in critically injured[1]	- overall mortality similar - increased mortality in non-critically injured
Jacobs et al (1984)	TS change	Critical injuries	Daily Intravenous	BLS ALS	98 80	-	- TS change significant in ALS, survival improved	- effect on survival not tested or demonstrated
Potter et al (1988)	Mortality	Severe trauma	Geography	BLS ALS	598/74[2] 472/96[2]	41%/73%[3] 35%/46%[3]	- 24hr mortality significantly lower in ALS	- overall mortality was not significantly different
Alexander et al (1984)	Mile-adjusted mortality rate	MVA trauma	Geography	BLS ALS	NS NS	44 1/24 5[4] 9 4/0 82[4]	- ALS associated with lower mortality rate	- ALS effect not independent of improved hospital care
Reines et al (1988)	% with increase in BP	MVA trauma	NS	BLS ALS	435 102	32% 12%	- ALS associated with increase in BP	- effect on survival not demonstrated
Pons et al (1985)	% with increase in BP/mortality	Penetrating thoracic/	NA	ALS	203	54%/18%[5]	- increase in BP/ - decrease in mortality	- no control group
Cwinn et al (1987)	Mortality	Blunt trauma	NA	ALS	114	16%	- high survival	- no control group
Honigman et al (1990)	Mortality	Penetrating Cardiac	NA	ALS	70	60%	- high survival in spite of severe injury	- no control groupe

1 Subgroup of patients with initial BP < 60 mmHg
2 Severely injured subgroup (ISS > 25)
3 24 hr mortality
4 In counties with trauma centres
5 Percent with increase in BP/mortality

Abbreviations
TS Trauma Score
BP Blood Pressure
MVA Motor Vehicle Accident
NS Not Stated
NA Not Applicable
BLS Basic Life Support
ALS Advarced Life Support

Table 2.7 Studies Opposing Advanced Life Support for the Pre-hospital Management of Trauma

Author	Type of Outcome	Patient Type	Comparison Method	Study Groups	N	Outcome	Results: Authors' conclusions	Results: Comments
Gervin et al (1982)	Mortality	Penetrating Cardiovascular	NS	ALS BLS	7 6	7 (100%) 2 (33%)	- Increased on-scene time caused 100% mortality in ALS group	- small numbers - treatment allocation method not described - group comparability not demonstrated
Ivatury et al (1987)	Survival	Penetrating Thoracic Injuries	NS	ALS BLS	51 49	1 (2%) 9 (18%)	- ALS increased time to definitive care and consequently increased mortality	- method of treatment allocation was not described
Cayten et al (1984)	Expected/ observed deaths	Trauma victims	NS	ALS BLS	37 65	O/E = 3/3 O/E = 7/4	- Excess mortality in ALS group due to increased delays to hospitalization	- small number of deaths - treatment allocation method not specified
Tsai et al (1987)	Mortality/ on-scene time	Pediatric emergency	NA	ALS	3184/ 1192[1]	10 minute increase in scene time	- ALS increased scene time without overall beneficial impact - 100% mortality in 23 cardiac arrests	- no control group - overall mortality not studied
Luterman et al. (1983)	Appropriate-ness of on-site care	Trauma victims	NA	ALS	919	ALS was provided un-nessarily for 41-71% of the patients not requiring ALS treatment	- Unnecessary ALS - Scene time required to perform ALS exceeded transport time time for majority of cases	- Impact of ALS in outcome not studied
Smith et al. (1985)	Change in TS/ Preventable deaths	Penetrating Injuries	NA	ALS/ I V used	52	TS did not change 5/14 deaths were pre-ventable	- Increased scene time for I V , without improvement in physio-logical status - 36% of deaths would be avoided if patients were transported to trauma centre directly	- No control group

Abbreviations, NS Not stated, NA Not applicable, ALS Advanced Life Support, BLS Basic Life Support, O/E Observed deaths (/Expected deaths

1 Trauma cases

Table 2 8 Results from the Houston RTC on PASG

	Author (Year)					
	Bickell et al (1985)		Mattox et al (1986)		Bickell et al [1] (1987)	
N	PASG 36	No-PASG 32	PASG 160	No-PASG 182	PASG 97	No-PASG 104
Mean TSo (± 1 sd)	9 9 ± 4 4	9 2 ± 4 9	9 8 ± 4 5	10 6 ± 4 5	11 8 ± 3 3	12 0 ± 3 5
Mean TSf (± 1 sd)	10 6 ± 5 9	9 8 ± 6 6	11 4 ± 5 9	11 5 ± 5 3	12 3 ± 5 1	12 3 ± 4 8
Response Time (min) (mean ± 1 sd)	5 6 ± 2 4	4 8 ± 2 4	5 7 ± 3 4	5 6 ± 3 1	5 1 ± 2 9	5 3 ± 2 8
Scene Time (min) (mean ± 1 sd)	17 7 ± 8 4	17 7 ± 9 6	17 8 ± 7 8	14 9 ± 7 1	17 3 ± 8 3	13 1 ± 7.9*
Transport Time (min) (mean ± 1 sd)	10 7 ± 4 3	10 9 ± 5 8	12 6 ± 4 9	11 2 ± 4 9	12 1 ± 4 9	11 3 ± 5.2
Mean (TSf - TSo)	0 7 ± 1 5	0 6 ± 1 7	1 6	0 4	0.5	0 3
Mortality (%)	---	---	30%	22%	31%	22%
Mean ISS (± 1 sd)	---	---	19 8 ± 12 2	21 0 ± 14 3	22 5 ± 11 1	22 6 ± 13 6

Abbreviations

TSo Scene Time Score

TSf Emergency room Trauma Score

TSf - TSo Change in Trauma Score between Scene and Emergency room

* P < 0 001

1 Includes only penetrating abdominal injuries

* p < 0 01

Table 2 9 I V Initiation Time, Scene Time, Transport Time

Author	Year	Case Type	N	I V time (min)	Scene time (min)	Transport time (min)	On-site Procedures
Smith	1985	BP = 0	9	8 6	16 2	8 2	I V
		BP ≤ 70 mmHg	15	12 6	17 3	8 5	
		BP 70-100 mmHg	28	11 5	14.5	10 5	
Cwinn	1978	Blunt	16	2 98	12 6	8 0	I V
		Blunt	114	--	13.9	8 0	I V , Intubation, PASG
Aprahamian	1985	Blunt + Penet	95	--	22 0		I V , Intubation
Jones	1985	Trauma/Medical	97	2 5	18.5	8 3	I V
Pons	1988	Trauma	51	2 2	11 0		I.V
		Trauma	50	--	9 4		no I V. attempted
Pons	1985	Penetrating	100	--	10.1	6 4	I V , Intubation
Honigman	1990	Penetrating	5	--	10 8		0 I V
			17	--	9 6		1 I.V
			39	--	11 2		2 I.V.s
			7	--	10 4		3 I V s
Reines	1988	MVA	435	--	24 8	14 4	ALS (I.V., intubation)
			102	--	18 9	15 8	BLS

Abbreviations

BP	Blood Pressure
MVA	Motor Vehicle Accident
I V	Intravenous line
ALS	Advanced Life Support
BLS	Basis Life Support
PASG	Pneumatic Anti-shock Garment

CHAPTER 3. PURPOSE AND METHODS

3.1. RATIONALE AND PURPOSE

3.1.1. Rationale

Urgences-Santé was established in 1981 and provides emergency medical services in the Montreal and Laval regions. The Urgences-Santé system is unique in North America in that physicians are routinely dispatched to the scene of the emergency so that they may provide on-site care to critically ill and injured patients. Physicians employed by Urgences-Santé may intubate, initiate intravenous lines, administer medication, and apply pneumatic anti-shock garments (PASG) to critically injured trauma victims. Basic life support (BLS) including extrication, spine and head immobilization, wound dressing, fracture splinting and oxygen administration may be provided at the scene by EMTs or physicians.

In contrast to EMS systems in the USA where advance life support (ALS) is provided by EMTs under direct communication with a physician, ALS in Montreal is provided directly by physicians. Problems which may exist in the USA systems include communication deficiencies, and lack of adequate training or experience of EMTs to assess and recognize severe injuries. In addition, difficulties may arise from the fact that the information on the patient's condition is provided indirectly to the MD, thus making an

overall or gestalt assessment difficult. These potential problems are not relevant to the Urgences-Santé system. Therefore, this system may theoretically be considered as representing a close to optimum level of on-site ALS.

Given the previous premise, Montreal provides a unique opportunity for the evaluation of on-site ALS on the outcome of trauma. Such an evaluation of a system where physicians provide on-site ALS would contribute considerable knowledge and evidence in the "Scoop and Run" vs. "Stay and Stabilize" controversy discussed in the previous chapters. Assuming that a beneficial effect of ALS as provided by Urgences-Santé physicians is not demonstrated, this would considerably shift the weight of the evidence towards the "Scoop and Run" side. If on-site ALS provided by physicians is not proven beneficial to trauma victims, there would be minimal incentive to train EMTs in such procedures or in maintaining systems implementing on-scene ALS for the pre-hospital management of trauma. On the other hand, should ALS in such a system prove beneficial, the evidence would lend support to the "Stay and Stabilize" side.

The effectiveness of any emergency medical system should be evaluated and compared to other systems in order to detect deficiencies and identify areas where improvements are necessary. Urgences-Santé has been in operation since 1981 and a study evaluating or describing this system has not been conducted. A study addressing these issues will

allow a comparison of Urgences-Santé with other EMS's and will identify areas where changes may be implemented.

The fact that hospitals in the Montreal area are not regionalized or organized with respect to the level of trauma care available, and the lack of patient triage protocols, are additional issues which should be taken into consideration. Trauma victims are transported by Urgences-Santé ambulances to the nearest hospital with an emergency room. Thus, similarly injured patients may be treated in hospitals with varying levels of trauma care. In evaluating emergency trauma services in Montreal, the impact of the level of trauma care available at the receiving hospital on the outcome should be considered and assessed. Results from such an evaluation could lead to recommendations for the regionalization of pre-hospital trauma care involving trauma centre designation and organization.

The purposes of the present study are: first, to describe the pre-hospital trauma services provided by Urgences-Santé; second, to describe the impact of these services on trauma-related mortality; and third, to assess the association between on-site ALS as provided by Urgences-Santé physicians and the risk of dying from severe injury, thus obtaining an estimate of the effectiveness of such ALS care in reducing trauma-related mortality.

3.1.2. Study Objectives

The specific objectives of the present study are:

1) To describe the Emergency Medical Services System of Urgences-Santé in Montreal as it relates to trauma.

2) To describe and estimate the impact of the emergency medical services in general, and the pre-hospital and in-hospital components on trauma-related mortality in Montreal.

3) To describe and estimate the association between on-site ALS provided by Urgences-Santé physicians and the risk of dying in severely injured patients.

3.2. OVERALL STUDY METHODS

3.2.1. Study Design

The purpose of the current study was to evaluate the impact of the emergency medical services in Montreal on injury related mortality. The study was designed to capture a sample of trauma patients for whom emergency medical assistance was requested from Urgences-Santé as it is the sole provider of pre-hospital emergency care in this region. This sample would have to be representative of the trauma patients for whom the quality of emergency care would be important.

As was mentioned in the previous chapters, the majority of trauma victims suffer only minor injuries and require minimal or no medical care. Only 10% of all trauma have injuries which require intensive medical care and only 5% require specialized hospital care (Cowley et al.,1982). The most substantial impact of medical interventions will be in reducing mortality in the patients with severe injuries given that minor injuries generally do not present a threat to life.

Most of the calls for trauma to Urgences-Santé are for cases of minor injuries and the nurse will request only an EMT to be dispatched. The cases for which an MD is requested involve more severe injuries. The cases for which originally only an EMT was requested but an MD was requested afterwards are also probably cases with severe injuries. In

consideration of the fact that the most appropriate population of patients for the evaluation of pre-hospital care are patients with severe injuries and that for these patients the nurse will generally request an MD we decided to first screen all calls for which an MD was requested. This would ensure that the original study sample would be representative of severely injured patients, i.e. for whom pre-hospital care is important.

In order to avoid the serious restriction of the spectrum of severity in the sample we decided to also include a sample of patients for whom an MD was not requested by the Urgences-Santé nurse. This was also done in order to obtain a sample of any false negatives, i.e. cases of severe trauma for whom the nurse did not request an MD. However, at the same time we recognized that there would be a high rate false positives in the first sample, i.e. cases of minor trauma, which required minimal or no care but for whom the nurse requested an MD.

The second sample was then selected so that we would focus on patients who were transported to a hospital with severe injuries and under sample from those with minor injuries. This was in the line with the rationale that was explained previously. The final study sample was selected solely on the basis of outcome so that a case-referent study would be conducted.

The sampling scheme leading to the final sample which is described in detail in Section 3.2.4. was designed to select a sample that would be appropriate for the evaluation of the association between the level of pre-hospital care and risk of dying in severely injured patients. This association would be considered as an estimate of pre-hospital care effectiveness. However, it was realized that although the bias associated with including all cases of minor trauma was reduced by this sampling. Selection bias may have been introduced by the possibility that severely injured patients treated by a physician had higher chances of being selected when compared to similar patients treated by an EMT. Given the previous discussion however, the magnitude of this bias was expected to be minimal.

The evaluation of the impact of the emergency system on mortality was a secondary objective which was conceived after the original study was developed. This was prompted by the publication and availability of data from the Major Trauma Outcome Study which provided the opportunity to compare the mortality in our sample with that in an external population.

However, the sampling process of our study resulted in a selective sample of severely injured patients with probability of dying higher than that of the entire sample of trauma victims. As a result, the comparison of our sample to that of the MTOS may yield an overestimated excess mortality.

The general limitations of observational studies, the evaluation of medical interventions, as well as the specific limitations of the current study and their impact on the results are discussed further in Chapter 5.

3.2.2. Data Sources and Record Linkage

Data on the date and time of the injury-event was recorded on the call-sheet by the nurses at Urgences-Santé, who receive all of the 911 telephone calls requesting ambulance assistance. The nurse determines the nature of the event as trauma, cardiac arrest, or other, and the seriousness of the situation. Based on this information, a priority rating is assigned and the nurse will decide what resources are required at the site. The information on the nature and priority rating of the event, as well as the resources requested, are recorded on the call-sheet by the nurse.

This information is transmitted to the dispatcher who coordinates the mobilization to the site of any available personnel stationed in a mobile stand-by station nearest to the accident site. The dispatchers record what resources were sent at the site, the time of the call, the time of dispatching, the time of arrival at the accident site of the ambulance and the emergency physician, the time of departure of the emergency crew with the victim from the site, and the time that the victim was brought to the hospital.

Physicians dispatched to the accident site record demographic data, information on the nature of the accident, the status of the victim upon arrival, several vital signs of the patient, and a description of the injury. Physicians also record the procedures performed on-site. All data recorded by the physicians are entered in the Urgences-Santé medical files.

The hospitals receiving patients by Urgences-Santé ambulances provided information on the final outcome and hospitalization details for these patients. Items of information obtained from the hospitals include admission status, the diagnoses, length of time in an intensive care unit (ICU), surgical procedures performed, the duration of hospitalization, and the discharge status of the patient. For patients subsequently transferred to other hospital(s), the same data were obtained from the transfer hospitals. Receiving hospitals provided Urgences-Santé with hospital unit numbers which could be subsequently used to identify patient charts to be further reviewed.

Information from the call-sheets, dispatch records, medical files and hospital reports at Urgences-Santé was extracted by a medical archivist and was entered in a personal computer using database software developed for this project. Hospital charts of selected severely injured patients identified from the hospital reports at Urgences-Santé were reviewed in order to obtain data on comorbidity,

and items required to compute Abbreviated Injury Scale (AIS) score and Injury Severity Score (ISS). Data abstraction from the hospital charts was conducted by the same medical archivist who extracted the data from the Urgences-Santé records.

All records from each data source were assigned a unique identifier which was created by combining the date of the event and the Urgences-Santé code for the event. Call-sheet records were cross-referenced with dispatch records in order to identify any calls for which a dispatch record was missing and vice-versa. Records identified from the medical files were cross-referenced with dispatch and call-sheet records. Similarly, hospital records were cross-referenced with call, dispatch, and medical file records. Hospital charts were identified from hospital records. Figure 3.1 shows the logical flow of information.

3.2.3. The variables of the Study

The data sources for all the study variables are summarized in Table 3.1. The study variables obtained directly or derived from the study data will be described in detail in this section. In order to maintain continuity and a logical sequence with the previous sections, the variables will be described in reference to the data source from which they originated.

A) Call sheet

Information recorded on this data form include the date and time of the call, the nature of the event, the priority assigned to the event by the nurse and the resources requested. The variables derived from these data are:

1 - Date of the event.

2 - Time of the event.

3 - Resources requested by the nurses;

They could be one of the following:

- Nothing at all.
- Ambulance with EMT only.
- Ambulance with EMT and MD.

B) Dispatch record

The dispatcher records the date of the event, the time of the call, what resources were requested by the nurse, the time that an ambulance was dispatched, the time that an MD was dispatched (if one was dispatched), the times that the ambulance and MD arrived at the scene, the time that the ambulance and patient departed from the scene, the time that the patient arrived at the hospital.

The variables derived from these data are:

1 - Date of the event.

2 - Time of the event.

3 - Resources requested by the nurse.

4 - Resources dispatched to the scene.

5 - Time interval from call to dispatch of ambulance.

6 - Time interval from call to dispatch of an MD.

7 - Time interval from call to arrival of ambulance at the scene: ambulance response time.

8 - Time interval from call to arrival of physician at the scene: MD response time.

9 - Time interval from arrival of ambulance at the scene to departure: scene time.

10 - Time interval from departure of the ambulance with the patient from the scene to arrival at the hospital: transport time.

11 - Total time: time from call to arrival of patient at the hospital.

C) **Medical file**

Information recorded by the physicians in the medical file includes the age and sex of the victim, the location of the accident, the mechanism of the injury, the status of the patient upon arrival of the physician, the body region injured, vital signs, and the type of on-site interventions applied.

In detail, the variables derived from these data are:

1 - Date of the event.

2 - Age of the victim.

3 - Gender of the victim.

4 - Location of the accident as one of the following:

- traffic
- home
- workplace
- other

5 - Mechanism of injury.

For traffic accidents, the following choice of mechanisms are possible:

- motor vehicle driver
- motor vehicle passenger
- bicycle rider
- motorcycle rider
- pedestrian
- other modes of transportation

For non-traffic accidents, the following choice of mechanisms are possible:

- gunshot
- stabbing
- fall
- drowning
- electrocution
- fire
- hanging
- laceration
- crushing
- machinery accident

- intoxication
- overdose
- physical conflict (fight)
- other

6 - Whether any of the following body regions was injured and if so whether the injury was penetrating:

- head or neck
- thorax
- abdomen
- vertebral column
- extremities

7 - Whether the patient was incarcerated.

8 - Whether the victim was deceased upon arrival of the physician.

9 - The following vital signs:

a) systolic blood pressure

b) pulse rate

c) respiratory rate

10 - Level of consciousness of the victim upon arrival of the physician as:

- conscious
- confused
- unconscious

11 - Pre-hospital Index (PHI) was calculated from data on pulse, respiratory rate, heart rate, and level of consciousness. When data items required for calculations of PHI were missing, a normal level of the vital signs was assumed.

12 - Whether any of the following procedures were performed at the scene:

- immobilization
- dressing of wounds
- administration of oxygen
- initiation of intravenous line
- intubation
- administration of medication
- application of Anti-Shock Garments (PASG).

D) **Hospital records**

The receiving hospitals provided information on the type of in-hospital care, the diagnoses upon arrival at the hospital or admission, the duration of hospitalization, and the status at discharge.

The following variables are derived from these data:

1 - Whether the patient was admitted.

2a- Whether the patient was admitted in an intensive care unit.

2b- The duration of the stay in an ICU.

3a- Whether any surgery was performed on the patient.

3b- The type of surgery performed.

4 - The diagnoses at arrival or admission of the patient to the hospital.

5 - The status at discharge as:

- deceased
- discharged alive
- transferred to chronic care facility

6 - Length of hospitalization for the injury.

E) <u>Hospital charts</u>

The hospital charts of a selected number of severely injured patients were reviewed. Data extracted from these charts included Abbreviated Injury Score codes (AIS,1985) for all injuries and the presence of any chronic pre-existing conditions.

The following variables were derived from these data:

1 - Abbreviated Injury Scores (AIS) scores for each of the following body regions:

- head/neck
- abdomen
- thorax
- extremities
- external

2 - Injury Severity Scores (ISS) were calculated from the AIS using the method described by Baker (Baker et al.,1974).

3 - Whether the patient suffered from any pre-existing condition in the following categories:

- Cardiovascular
- Pulmonary
- Renal
- Cirrhosis
- Diabetes
- Cancer

F) <u>Level of Trauma Care at Receiving Hospital</u>

The patients in this study were transported to 33 different hospitals in the Montreal area. Although none of these hospitals are recognized or organized as trauma centres, 11 of these are affiliated with one of the two Montreal medical schools. These teaching hospitals provide around-the-clock emergency room coverage and a surgical resident or staff is present or on-call at all times.

Three physicians, two surgeons-in-chief, one from each of the two medical schools, and an emergency physician who is the medical director of Urgences-Santé, were asked to assess the level of trauma care available at each one of these hospitals.

These assessors were chosen because of their involvement in trauma care and their extensive experience in trauma research. These assessors were:

Dr. David Mulder, Surgeon-in-Chief of the Montreal General Hospital, former chairman of the Department of Surgery of McGill University. Dr. Mulder has served as the Chairman of the American Trauma Association and has been extensively involved in trauma research.

Dr. Leon Dontigny, is a trauma surgeon at Sacré-Coeur Hospital and Director of Québec Trauma Incorporated, a non-profit organization devoted to trauma-related research in Quebec. Dr. Dontigny is a professor of surgery at the University of Montreal medical school.

Dr. Mathias Kalinas is the Medical Director of Urgences-Santé. His duties are to ensure the quality of care provided by Urgences-Santé physicians and technicians. Dr. Kalinas has had extensive experience on research in the area of pre-hospital care of trauma and cardiac arrest, and in the organization of emergency medical systems.

The American College of Surgeons classification of trauma hospitals was used as a frame of reference in classifying the level of in-hospital trauma care. Thus, the three physicians were asked to assign a classification for each hospital as ACS-level I, II, or III compatible with respect to the personnel and care available. However, this does not imply that any of these hospitals would actually qualify as level I or II trauma centres with respect to the internal organization of the trauma care. The term ACS-classification compatibility for the hospitals in this study

refers to the classification assigned to these hospitals by the three physicians.

Each physician classified the hospitals independently, without knowledge of the results or the classification assigned by the other assessors. Furthermore, the assessors were not aware of any hypothesis related to the classification of the hospitals. In case of disagreement, the classification assigned by two of the three physicians was used. There was only one such disagreement. There were no three-way disagreements.

Of the 33 hospitals in this study, three were classified as ACS-level I, and eight were considered as ACS-level II compatible. The remaining 22 hospitals provide minimal care to trauma victims and were considered as ACS-level III compatible.

Appendix F shows a mp of the Montreal and Laval areas with the location of the hospitals.

3.2.4. Sampling

Assembly of Original Sample (Phase I)

Figure 3.2. shows the sampling procedures leading to the first sample (Sample I). The first step in assembling the original study sample involved reviewing all Urgences-Santé medical records completed by the physicians during the period of the study (April 1, 1987 - March 31,1988) and selecting the ones for which trauma was indicated. The next step involved reviewing the Urgences-Santé call-sheets which were completed by the nurse at the time of the call to

Urgences-Santé. All call-sheet records for which trauma was indicated and the nurse requested an ambulance and a physician to be sent at the scene, were selected and included in the original sample. The third step in assembling the original study sample involved the review of all Urgences-Santé call-sheet records for which an MD was not requested, for one out of every eight days during the last seven months of the study. Records for which top priority trauma was indicated were selected and included in the sample. This represents a 7.3% sample (1/8 days for 7/12 months) of the patients that were treated by an EMT only. The medical files, call-sheets and dispatch records for which an MD was requested were cross-referenced.

Follow-up to Hospital (Phase II)

The second sampling phase and the sampling fractions leading to the second sample are shown in Figure 3.3. Pre-hospital Index (PHI) scores on the patients treated by an MD at the scene were calculated from information on vital signs reported by the physicians on the Urgences-Santé medical records. Based on these PHI scores, trauma was classified as severe (PHI > 3) and mild (PHI ≤ 3) according to the recommendations by Koehler (Koehler et al.,1986). From the patients in the first sample that were treated by an MD and were transported to a hospital by the Urgences-Santé ambulance, all (100%) of those with severe trauma (PHI > 3)

and a random 10% sample of those with mild trauma (PHI ≤ 3) were followed to the hospital and were included in the second sample (Sample IIa').

Because determination of PHI scores required information recorded by the physicians at the scene of the injury, this measure was not available for trauma victims for whom a physician was not present at the scene. For this patient group, a randomly selected 10% sample of those transported to a hospital by an Urgences-Santé ambulance were included in the second sample (Sample IIc').

Selection of final sample (Phase III)

The complete sampling scheme leading to the final sample is shown in Figure 3.4. The final sampling phase was aimed at further refining the sample of trauma victims so that they would be appropriate for the evaluation of emergency trauma services. As was mentioned previously, patients with minor injuries have a high survival probability regardless of the quality of medical care. At the other end of the spectrum, extremely severe or fatal injuries will cause death in spite of adequate care. Emergency trauma care is irrelevant for the two extremes of injury severity i.e. fatal and minor. However, the outcome of patients with severe but survivable injuries depends largely on emergency medical services. Patient groups with such intermediate injuries are most appropriate for the evaluation of emergency trauma care.

Another dimension of identifying trauma patients appropriate for the evaluation of emergency medical care is related to the time to death. As was previously discussed, immediate deaths occur within two hours from the injury and are generally non-preventable. Prevention of late deaths, i.e. those occurring after a week from the time of the injury depends on long-term hospital care rather than on the quality of the emergency services. Consequently, prevention of early deaths, i.e. those occurring between one hour and seven days from the time of the injury, depends predominantly on the emergency medical care provided. These patients comprise the appropriate population for the evaluation of emergency trauma care.

Patients from the second sample (Sample II) were selected to be included in the third sample (Sample III) on the basis of the outcome. The intent was to select the appropriate cases and referents for the evaluation of pre-hospital trauma services. Thus, the cases had to be patients with severe injuries who died after the ambulance arrived and before seven days from the time of the injury. The appropriate referents were patients with severe injuries that survived at least seven days from the time of the accident. The criteria for being included in the third sample as a case were:

1) the patient had to be alive at the time of the arrival of the ambulance, and,
2) the patient was transferred to a hospital by an Urgences-Santé ambulance, and,
3) the patient died within seven days (0-6) from the time of the injury.

The criteria for being included in the third sample (Sample III) as a referent were:

1) the patient had to be transferred to a hospital by an Urgences-Santé, and,
2) the patient survived for at least seven days post-injury, and,
3) the patient fulfilled any of the following criteria:
    a) was admitted into the hospital as a result of the injury, or,
    b) had surgery,
    c) was treated in an intensive care unit, or,
    d) had an on-site pre-hospital index (PHI) > 3.

One of the critical issues in selecting subjects for a case-referent study is to avoid selection on the basis of exposure, thus preventing selection bias. Although the cases and referents that were included in Sample III were selected solely on the basis of outcome, the selection of patients for Samples I and II was influenced by the presence

of a physician and therefore treatment by ALS. This introduces the possibility of selection bias prior to the final sample selection. The impact of this bias will be discussed in detail in Chapter 5. Because of these issues related to the selection of the sample, this aspect of the study may not conform to the strict definition of a case-referent design. However, the terms "case-referent", and "cases" or "referents" will be used to refer to this part of the study and to the subjects fulfilling the criteria as described previously.

Table 3.1 indicates which data sources contribute variables to the three study samples. Data from the medical files were not available for the patients not seen by an MD, specifically for patients in Samples Ic, IIc, and IIIc. For the other samples, data from every data source were available.

3.3. METHODS TO MEET SPECIFIC STUDY OBJECTIVES

3.3.1. Description of Emergency Medical Trauma Services

There were four distinct groups of trauma patients with respect to the type of services requested by the Urgences-Santé nurse and the services that were dispatched to the scene. Figure 3.5 shows the formation of these groups:

The groups described in Figure 3.5 are the following:

1) The patients for which the nurse requested both an ambulance and an MD and both were dispatched to the scene (Group I).
2) The patients for which the nurse requested both an ambulance and an MD and only an ambulance with an EMT was dispatched (Group II).
3) The patients for which the nurse requested only an ambulance, but, an MD was subsequently dispatched as requested by the EMT (Group III).
4) The patients for which only an ambulance with an EMT was requested and dispatched (Group IV).

The original sample (Sample I) was described with respect to the proportion of calls in each one of these groups. The ACS-compatibility of the hospitals receiving trauma victims in each one of these groups was described, and differences in distributions of receiving hospitals between the patient groups (I-IV) were evaluated using the Chi-Square test.

The system times, specifically response (call to arrival of ambulance), scene (arrival at scene to departure), transport (departure from scene to hospital arrival), and total (call to hospital arrival) were described for the entire sample using appropriate weights to adjust for the proportions sampled. These times were described separately for each one of the groups described previously. Analysis of variance (ANOVA) will be used to evaluate the difference in the means of each one of these time intervals between the four groups. Tukey's Least Significant Difference (LSD) test was used to detect significant differences between pairs of groups with respect to these time intervals. This method uses Tukey's honestly significant difference method which evaluates all pairwise comparisons while taking into account the number of means in the entire set. This method, however, has limited applications to groups of unequal size (Ferguson,1971:297-300). Student's t-test using Bonferroni correction for multiple comparisons was used to further evaluate the differences in system times between pairs of groups when the size of the groups is not equal (Ingelfinger et al.,1987:161-162).

The sample of trauma patients for which a physician was dispatched to the scene were described in terms of demographic characteristics (age, gender), the location of the accident, the mechanism of injury, the specific body

regions and the number of body regions injured, injury severity as measured by the Pre-hospital Index (PHI), and the on-site procedures performed. This sample was used to evaluate the association between the level of on-site care with scene time.

The following patient groups were identified with respect to the level of on-site care provided by the MD.

1) No procedures performed.
2) Basic Life Support only (BLS), i.e. any of the following procedures: extrication, immobilization of head and/or spine, wound dressing, fracture splinting, administration of oxygen and initiation of cardiopulmonary resuscitation.
3) Advanced Life Support (ALS), any of the following procedures: intubation, initiation of intravenous lines, administration of medications, and Application of Pneumatic Anti-Shock Garments (PASG).

The latter group was further subdivided according to the number of ALS procedures performed (Range: 1 - 4), thus defining the following six distinct groups: no procedures, BLS-only, 1 ALS procedure, 2 ALS procedures, 3 ALS procedures, and 4 ALS procedures.

Analysis of variance (ANOVA) was used to detect significant differences in the mean on-scene and total pre-hospital time between the groups described above. Tukey's

LSD method and Student's t-test using Bonferroni inequality correction was used to detect significant between group differences. Multivariate linear regression was used to assess the impact of on-site care on-scene time while controlling for injury severity as measured by the PHI. In this analysis, the on-site care was coded as an ordinal variable with a range of 0 - 6, (0 = EMT only, 1 = MD no procedures, 2 = MD only BLS, 3 = MD + 1 ALS procedure, 4 = MD + 2 ALS procedures, 5 = MD + 3 ALS procedures, 6 = MD + 4 ALS procedures), the PHI and scene time was entered as continuous variables.

The patients who were followed to the hospital (Sample II) were described with respect to the in-hospital treatment received and discharge status. For the fatalities in this sample, the distribution of the number of days to death was also presented.

The final sample (Sample III), of severely injured patients was described with respect to demographic characteristics (age, gender) and presence of a pre-existing condition in any of the following categories: Cardiovascular, Renal, Pulmonary, Diabetes, Cirrhosis, and Cancer.

3.3.2. Description and Estimation of the Impact of Emergency Medical Services on Trauma Mortality in Montreal

The impact of the emergency medical services on trauma-related mortality in Montreal was evaluated by comparing the mortality in the sample of severely injured patients (Sample III) with those expected by indirect standardization to the following standard populations.

1) The data presented by Bull on the mortality of 1333 cases of traffic accidents (Bull,1975). The data presented in this study provide the following equations for the determination of the probit of death according to patient's age and ISS.

Age: 15 - 64 yrs :

$$\text{probit} = 0.0820 + 1.748 \times \text{ISS}$$

Age: 45 - 64 yrs :

$$\text{probit} = 0.1173 \pm 1.558 \times \text{ISS}$$

Age: $\geq$ 65 yrs :

$$\text{probit} = 0.1469 + 2.031 \times \text{ISS}$$

In the present study, the probit equation for patients between 15 - 44 years of age will be also used for patients under 15 years of age. Probit values will be converted to probabilities by the method suggested by Armitage et al. (1987:364-366).

2) In a recent prospective study on 592 adult (> 15 years) patients with blunt injuries from Toronto, Ontario, McLellan reported the following logistic regression formulae for the probability of death based on the patient's age, ISS, and presence of isolated head injury (McLellan et al.,1989).

a) Without isolated head injuries:

$$\text{Probability of Death} = \frac{1}{1 + e^{-(-9.09 + 0.05 \times \text{Age} + 0.17 \times \text{ISS})}}$$

b) With isolated head injuries:

$$\text{Probability of Death} = \frac{1}{1 + e^{-(-11.06 + 0.06 \times \text{Age} + 0.20 \times \text{ISS})}}$$

3) In a 1988 article, Copes, Sacco and Champion published the probabilities of death for specific ISS scores, patient age groups (< 50 and ≥ 50 years), and type of injury (blunt vs. penetrating). These results were obtained from data on 14,786 trauma patients from the Major Trauma Outcome Study (MTOS) with the participation of 111 hospitals in the USA and Canada (Copes et al.,1988).

4) Another method of predicting mortality in trauma victims using the data from the MTOS sampling is the TRISS method, which is most comprehensively described by Boyd et al. (1987). The TRISS method derives a probability of survival for trauma patients on the basis of patient's age, Trauma Score (TS), and ISS, by using the following logistic regression equations:

a) Blunt Trauma:

$$\text{Probability of Survival} = \frac{1}{1 + e^{-(-1.2470 + 0.9544 \times TS - 0.0768 \times ISS - 1.9052 \times Age)}}$$

b) Penetrating Trauma:

$$\text{Probability of Survival} = \frac{1}{1 + e^{-(-0.6029 + 1.1430 \times TS - 0.1516 \times ISS - 2.6676 \times Age)}}$$

For each patient, the probability of death was calculated as 1 - (Probability of survival).

Using these four standard populations, the expected number of deaths in the final sample (Sample III) was calculated by adding the individual probabilities of death for each patient:

Therefore:

$$\text{Expected deaths} = \sum_{i=1}^{n} Pd_i$$

where: Pd_i = Probability of death for the i^{th} patient.

The observed/expected ratio of deaths was then calculated using this value of expected deaths. This ratio is similar to the Standardized Mortality Ratio (SMR). In fact, the definition of the SMR as shown by Breslow and Day is: (Breslow & Day,1987:65-66).

$$SMR = \frac{\sum_{j=1}^{J} d_j}{\sum_{j=1}^{J} n_j \mu_j} = \frac{O}{E}$$

$j=1$

where: $\Sigma\ d_j$ = observed deaths = 0, and

$n_j\ \mu^*_j$ = expected number of deaths in the group for the j^{th} level of the risk factor. The value μ_j represents the probability of death according to the standard proportions for the j^{th} level of risk, usually age, but in this study the probability was determined by the various methods described previously. The value n_j is the total number of subjects with the j^{th} level of risk.

The total number of expected deaths is therefore:

$$\Sigma\ n_j\ \mu_j = E$$

Although the use of SMRs implies the study of the mortality experience in different cohorts, the principle of comparing observed and expected number of deaths is the same. Therefore, although this discrepancy is noted, the term SMR or standardized ratio was used to refer to the ratio of observed and expected deaths.

The ratio of observed to expected deaths was considered as a measure of the impact of the emergency medical system on trauma-related mortality. Observed to expected ratios less than unity indicate that the system is efficient since the number of deaths observed is less than the number expected according to the age and injury severity (ISS) distribution of the study sample. The impact of different levels of on-site care, ACS-compatibility of the receiving hospital, and total pre-hospital time on trauma-related

to expected deaths in groups of patients classified according to these parameters. Specifically SMRs for the following groups were calculated:

1) With respect to on-site care.
   a) 4 group classification:
      1) Ambulance with EMT only
      2) MD on-site with no procedures performed
      3) MD on-site only BLS procedures performed
      4) MD on-site any ALS procedures performed
   b) 2 group classification:
      - BLS only: groups 1-3 from the above classification
      - ALS: group 4 from the above classification
2) With respect to ACS-compatibility of the receiving hospital.
   3 group classification:
   ACS-compatibility: I/II/III
3) With respect to time to arrival at the hospital:
   a) 5 group classification: (minutes)
      Time to hospitalization: 0-15, 16-30, 31-45, 46-60, > 60
   b) 2 group classification: (minutes)
      Time to hospitalization: ≤ 60, > 60

The standard sample for the above mentioned analyses was that presented by Copes from the MTOS (Copes et al.,1988).

The sample presented by Bull et al. (1975) was not used because of the long interval between the accumulation of data on the standard population and the study (1969 vs. 1987). In addition, the equations presented by Bull were derived using the original version of the Abbreviated Injury Scale (AIS-76), whereas the current study used the 1985 version of the AIS (AIS-85). The sample reported by McLellan was not used because the data were obtained from data on only blunt injuries in adults (> 15 years of age). The sample of the current study included both penetrating and blunt trauma as well as patients younger than 15 years of age. Finally, the TRISS method was not be used because of low number of patients with data on the Trauma Score. Only 103 patients in our sample had Trauma Scores determined by the physician at the scene of the accident. The MTOS population is preferable because of the large sample size, (14,786) the inclusion of penetrating and blunt trauma, and patients younger than 15 years old.

A method to compare the mortality of a study sample with that of another sample or standard population using observed and expected deaths was developed by Flora (Flora,1978). The difference between the observed and expected deaths is assessed using the Z statistic which is computed by the following formula:

$$Z = \frac{O - E}{(\Sigma\ Pd_i \times Ps_i)^{\frac{1}{2}}}$$

where: O = Observed number of deaths

E = Expected number of deaths

Pd_i = Probability of death for i^{th} patient

Ps_i = Probability of survival for i^{th} patient $=1-Pd_i$

The values of the Z statistic follow the standard normal distribution. Therefore, values over 1.96 indicate that the difference between the observed and expected deaths is significant at an $\alpha = 0.05$ (two-sided). Values above 2.58 indicate significant differences at $\alpha = 0.01$ (two-sided).

In the original article by Flora, the author notes that the procedure is reliable only for expected and observed deaths over 30 (Flora,1978). Because the number of observed and expected deaths for some of the patient groups is likely to be less than 30 a square root transformation was applied to the statistic developed by Flora. This transformation would stabilize the variance thus compensating for the small numbers (Armitage et al.;1978:362-363).

The transformed Z statistic was calculated for patient groups with small number of observed and expected deaths and was then compared with the original Flora Z statistic. When these were different both were reported.

Between group differences in the observed/expected death ratios were evaluated using the methods suggested by Breslow and Day. According to this method, the differences between groups with respect to the differences between observed and expected deaths follow an approximate Chi-

square distribution under the null hypothesis. This test statistic assesses the between group differences with respect to the difference between observed and expected deaths adjusted for the total number of expected (E^*_k) deaths.

The X^2 for these between group differences is calculated using the following formulae:

$$X^2_{K-1} = \sum_{k=1}^{K} \frac{(O_K - E^*_K)^2}{E^*_K}$$

The X^2 critical values are determined by the X^2 distribution with K-1 degrees of freedom.

This method has also been modified for testing trends in different levels of the exposure or group variable (Breslow & Day,1987:91-103).

The formula for the X^2 testing the trend statistic is:

$$X^2_1 = \frac{\left[\sum_{k=1}^{K} X_K (O_K - E^*_K)\right]^2}{\sum_{k=1}^{K} X^2_K E^*_K - \left(\sum_{k=1}^{K} X_K E^*_K\right)^2 / O_T}$$

where: X_K = the level of exposure or the arbitrary group number

where: K = number of groups

O_K = Observed number of deaths in the K^{th} group

$$E^{*}_{K} = \frac{O_T \; E_K}{E_T}$$

where: O_T = Total number of observed deaths

E_T = Total number of expected deaths

E_K = Total expected deaths in K^{th} group

Multivariate regression models incorporating external standard rates as suggested by Breslow and Day (1971:151-153) were used to estimate the impact of on-site care, ACS-receiving hospital compatibility, and pre-hospital time, on the ratios of observed to expected deaths. In this model the expected log odds of dying [log (expected deaths/expected survivors)] is included as the OFFSET using GLIM software for fitting of logistic models. Therefore, this value is used as the comparison odds in determining the coefficient values as opposed to the overall odds used in standard logistic models without the OFFSET options. The results will be expressed as odds ratios and the 95% confidence intervals derived from the logistic regression coefficients will be calculated using the method described in Kelsey et al. (1986:117-119). These odds ratios are interpreted as the estimate of the relative odds for dying associated with the specific exposure while accounting for the expected mortality as determined from the MTOS sample as a standard. This may therefore be considered a measure of

the impact of the specific determinant to the observed/expected death ratio or SMR. The adequacy of the logistic model was evaluated using the scaled deviance. Values of the scaled deviance equal to or approximately equal to the degrees of freedom indicate adequate fit of the model.

3.3.3. Description and Estimation of the Association between On-site ALS and Trauma-related Mortality Risk

3.3.3.1. Study Design and Definitions of Cases and Referents

An unmatched case-referent study design was used to address this objective. Patients included in the final sample (Sample III), were classified as cases or referents according to the following definitions:

Case: The patient was alive at arrival of the ambulance and died before seven days, i.e. within 0 - 6 days from the time of injury.

Referent: The patient survived for at least seven days following the time of the injury.

The exact description of the cases and referents based on the selection procedure for the final sample were the following:

Case:

- Emergency medical care was provided by Urgences-Santé.
- The patient was alive at the time of the arrival of the ambulance.
- The patient was transferred to a hospital by an Urgences-Santé ambulance.
- The patient died after arrival of the ambulance at the scene and within seven (≤ 6) days from the time of the injury.

Referent:

- Emergency medical care was provided by Urgences-Santé.
- The patient was either admitted into the hospital and/or had surgery or required care in an ICU unit or had an on-site PHI > 3.
- The patient survived for more than six days from the time of the accident.

3.3.3.2. Definition of Treatment Categories

Patients were classified into either an advanced life support (ALS) or basic life support (BLS) intervention group on the basis of the on-site care received using the following definitions:

BLS:

- Only EMT and ambulance at scene or
- MD at scene, no procedures performed or
- MD at scene, only BLS procedures performed, specifically any of the following procedures: extrication, wound dressing, fracture splinting, neck or spine immobilization, oxygen administration, and cardiopulmonary resuscitation.

ALS:

- MD at scene, at least one ALS procedure performed, specifically any of the following: intubation, initiation of intravenous lines, administration of medications, and application of Pneumatic Anti-Shock Garment (PASG).

The definition and distinction of the treatment categories requires some elaboration. The ALS group consisted of patients for whom an MD was present at the scene and decided to perform at least one ALS procedure. The decision to use such interventions were primarily based on the cond'tion of the patient as well as the nature and the severity of the injury. The distance from a hospital may have been a factor in deciding whether ALS would be used. The important point to be considered is that the allocation of patients to receive on-site ALS was not random

but was based on the judgement of the physician which may have been influenced by the condition of the patient, the injury characteristics, and distance from the hospital. Other factors including previous experience, personal biases or beliefs may have also influenced this decision. We did not have the means to determine why ALS was or was not used.

By strict definition, the use of BLS implies that under all circumstances, the patient is transported immediately to the hospital without any attempts at ALS. This further may imply that ALS is not available. However, in this study, only the patients for whom an EMT only was present at the scene conform to this definition. The BLS patients for whom an MD was present had ALS available but the MD decided not to use any ALS procedures. Similarly with the decision regarding the use of ALS, the decision not to use ALS may have been based on the condition of the patient, the injury severity, the distance from the hospital or personal beliefs and experiences of the physicians.

These facts may cause the two treatment groups to be different with respect to the factors which are prognostic of mortality. This phenomenon has been recognized as a potential problem in observational or survey-type impact studies as susceptibility bias. The impact of this bias on the results will be discussed in Chapter 5.

3.3.3.3. Estimation of the Association between ALS and Odds of Dying

3.3.3.3.1. Univariate and Bivariate Analyses

The crude odds ratio was used to obtain an unadjusted estimate of the relative odds of dying (being a case) associated with ALS (being in the ALS group). In order to identify potential confounders, the differences between cases and referents as well as between patients in the ALS and the BLS groups with respect to the following parameters was evaluated. Age, as a continuous variable and in 15-year interval categories, comorbidity, (cardiovascular, renal, pulmonary, diabetes, cirrhosis, cancer), location of accident, mechanism of injury, body region injured, number of regions injured, (range: 0 - 5), injury severity, (ISS, TS), System times, (response, scene, transport, total), ACS-compatibility of receiving hospital.

Differences between groups with respect to the means of continuous variables was evaluated using Student's t-test. Between group differences with respect to the distribution of categorical variables were assessed using the Chi-square statistic. For ordinal categorical variables, the Chi-square test for trend was used. Odds ratios were used to evaluate the association between exposure at specific levels of categorical variables and being a case (odds of death), or being treated by ALS (odds of exposure). Approximate 95% confidence intervals of odds ratios were calculated using

Woolf's method (Schlesselman,1982:176-177).

Odds ratios estimating the relative odds of being a case associated with being in the ALS group for strata of the following variables were computed: age, comorbidity, location of accident, AIS scores of body regions injured, type of injury, ISS, time to hospitalization, and ACS-compatibility of receiving hospital. Adjusted odds ratios for each of these stratification variables were calculated using the Mantel-Haenzel method (Schlesselman, 1982:183-190).

3.3.3.3.2. Multivariate Analyses

Multivariate unconditional logistic regression was used to obtain adjusted estimates of the relative odds of dying associated with ALS while controlling for other variables associated with, or potentially associated with trauma mortality.

The logistic regression model is a multivariate method for analyzing data with a dichotomous outcome. The adaptation of the logistic model to case-control studies has been justified and supported by several authors as a valid multivariate method (Schlesselman,1982:227-230; Breslow & Day,1987:192-243). The main requirements for non-biased estimates in a case-control studies is that the subjects are selected exclusively on the basis of outcome or disease and that no selection process according to exposure is used

(Breslow & Day,1987:202-205; Anderson et al.,1980:171). Thus, the exposure is randomly distributed within the study sample and the chance of being selected is equal for both exposed and non-exposed cases and for exposed and non-exposed controls. Although the cases and referents were selected on the basis of outcome only (Sample III), the selection of the previous samples, (Sample I, Sample II) involved different sampling from the different intervention groups. The effect of this was discussed previously and is further elaborated in Chapter 5.

Variables showing significant association with the outcome and the treatment were included in the models. Additional variables which were included in the models represent factors which have been identified in the literature as being associated with the outcomes of injury and for which data were available. The literature which was outlined in Chapter 1 has suggested that age, type of injury, body region injured, and the presence of comorbid conditions are important determinants of the outcome of severe injury.

In addition, variables representing total pre-hospital time as well as ACS-compatibility of the receiving hospital were included. Injury severity scores (ISS) were used to adjust for the injury severity in the analyses.

The logistic models tested were progressively more complex. The first model was designed to evaluate the association between on-site care and the odds of dying while controlling for important predictors. The second model introduced the interaction term of ISS and on-site care in order to assess the potential effect modification of injury severity on the association between ALS and the odds of dying. The third model was similar as the first, however, in place of the ISS the individual body site ALS were introduced. This was done in order to control for the independent effect of the severity of injury in each body region.

Because the interaction effect of ALS * ISS was not significant and the coefficient for ALS did not change after introducing the individual ALS scores the first model was chosen as the basis for further analysis. Subsequent models introduced variables representing pre-hospital time and level of care at the receiving hospital.

1) Model I:

A model with being a case or a referent as the dependent variable (referent = 0, case = 1), and the following covariates: patient characteristics, body regions injured, type of injury and injury severity as covariates, and use of ALS as the principal predictor variable (ALS = 1, BLS = 0). Specifically the following variables comprised the model:

1) Outcome: Dichotomous (Case/Referent: 1/0)

2) Primary independent variables: On-site care:

Dichotomous (ALS/BLS:1/0)

3) Patient characteristics:

Age: Continuous

- Gender: Dichotomous (M/F: 1/2)
- PEC: Pre-existing comorbidity: This was a dichotomous variable coded as PEC = 1 if a comorbid condition existed from any of the following categories: cardiovascular, pulmonary, renal, diabetes, cirrhosis, cancer, and 0 otherwise.

4) Injury Characteristics:

Body Region Injured:

- Head or neck: Dichotomous (Yes/No: 1/0)
- Chest: Dichotomous: (Yes/No: 1/0)
- Abdomen: Dichotomous: (Yes/No: 1/0)

Multiple Body Regions Injured:

- Dichotomous: Coded as 1 if more than one region was injured, as 0 if only 1 body region was injured.
- Type of Injury:

  Dichotomous: (Penetrating/Blunt: 1/0)
- Injury Severity:

  ISS score: categorical;

1 = ISS: 1-14

2 = ISS: 15 - 24

3 = ISS: 25 - 59

2) Model II:

Model I with the addition of a term representing the interaction between on-site care and injury severity. This was used to evaluate whether the association of ALS with odds of dying was different for various ISS levels.

3) Model III:

Model I with replacement of ISS categories by AIS scores of individual body sites specifically: Headneck, Chest, Abdomen, Extremities, Face, External.

4) Model IV:

Model I with addition of variables representing the in-hospital care:

1) ACS-compatibility of receiving hospital:

Categorical: 1 = ACS: III

2 = ACS: II

3 = ACS: I

5) Model V (Final Model):

Model IV with the addition of a variable representing the time from the call to Urgences-Santé to arrival at the hospital.

1) Time to Hospital:

Categorical: 0: 0 - 60 minutes

1: > 60 minutes

Stepwise logistic regression was used to identify the most adequate model from the variables included in the final model. If level of on-site care and/or ACS-compatibility were not selected by the stepwise procedure they will be forced into the final model.

3.3.4. Assessment of Logistic Models and Power

Adequacy of the fit for the logistic models was evaluated using the Goodness of fit Chi-square statistic. Non-statistically significant Chi-square values indicate small deviation of the observed values and those predicted by the model, thus indicating adequate fit.

Multicollinearity among covariates was assessed by reviewing the correlation matrix of the logistic regression coefficients. Correlation coefficients greater than 0.7 will be considered as indicating significant colinearity.

As this study was explorative in nature, a priori power and sample size calculations were not performed. The range of the 95% confidence intervals of the point estimates will be used as indicators of precision, and of the range of possible values of the estimates.

Table 3.1 Study Variables by Data Source

	Data Source				
	Call Sheet	Dispatch Record	Medical File	Hospital Record	Hospital Chart
Date of accident	*	*	*	*	*
Time of accident	*	*	*		
Resources Requested	*	*			
Resources Dispatched		*			
Time of Call to Dispatch[1]		*			
Response Time[1]		*			
Scene Time		*			
Transport Time		*			
Total Time		*			
Patient Age			*	*	*
Patient Gender			*	*	*
Location of Accident			*	*	
Mechanism of Injury			*	*	
Patient Status at Arrival of EMD			*		
Body Regions Involved			*	*	
Vital Signs at Scene			*		
Pre-hospital Index at scene			*		
On-site Procedures Performed			*		
Admission into Hospital				*	*
In-hospital Care				*	*
Diagnoses at Hospital		*		*	*
Discharge Status				*	*
Length of Hospitalization				*	*
AIS/ISS Scores				*	*
Comorbidity					*

1 For ambulance and MD

Table 3.2 Data Sources and Study Samples

Data Source	Ia'	Ib'	Ic'	IIa'	IIb'	IIc'	IIIa'	IIIb'	IIIc'
Call Sheet	*	*	*	*	*	*	*	*	*
Dispatch Record	*	*	*	*	*	*	*	*	*
Medical File	*			*			*		
Hospital Record	*	*	*	*	*	*	*	*	*
Hospital Chart	*	*	*	*	*	*	*	*	*

Figure 3 1 Flow of Information between Data Sources

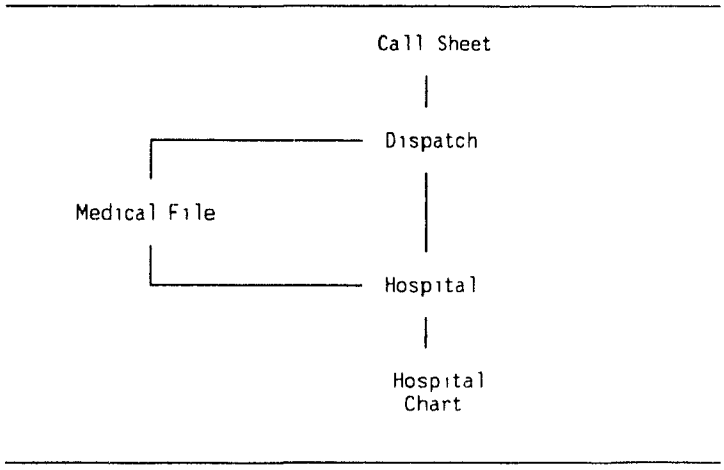
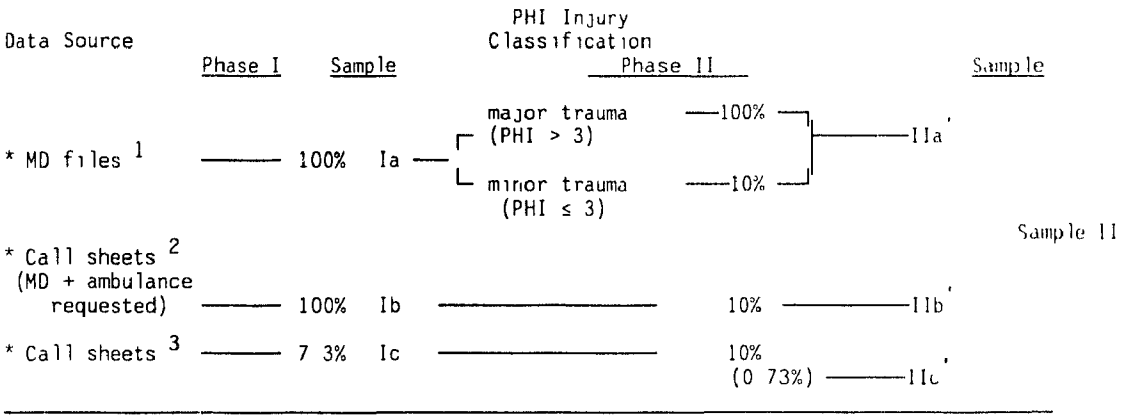


Figure 3 2 Assembly of Original Sample (Phase I, Sample I)

Data Source	Phase I			
* MD files	All Potential Trauma	→	100% (Sample Ia')	
* Call sheets	All Potential Trauma MD and ambulance requested by nurse	→	100% (Sample Ib')	Sample I
* Call sheets	Top Priority Trauma MD not requested by nurse	→	7 3% (Sample Ic') [1/8 * 7/12 = 0 073]	

Figure 3 3 Assembly of Second Sample (Phase II, Sample II)

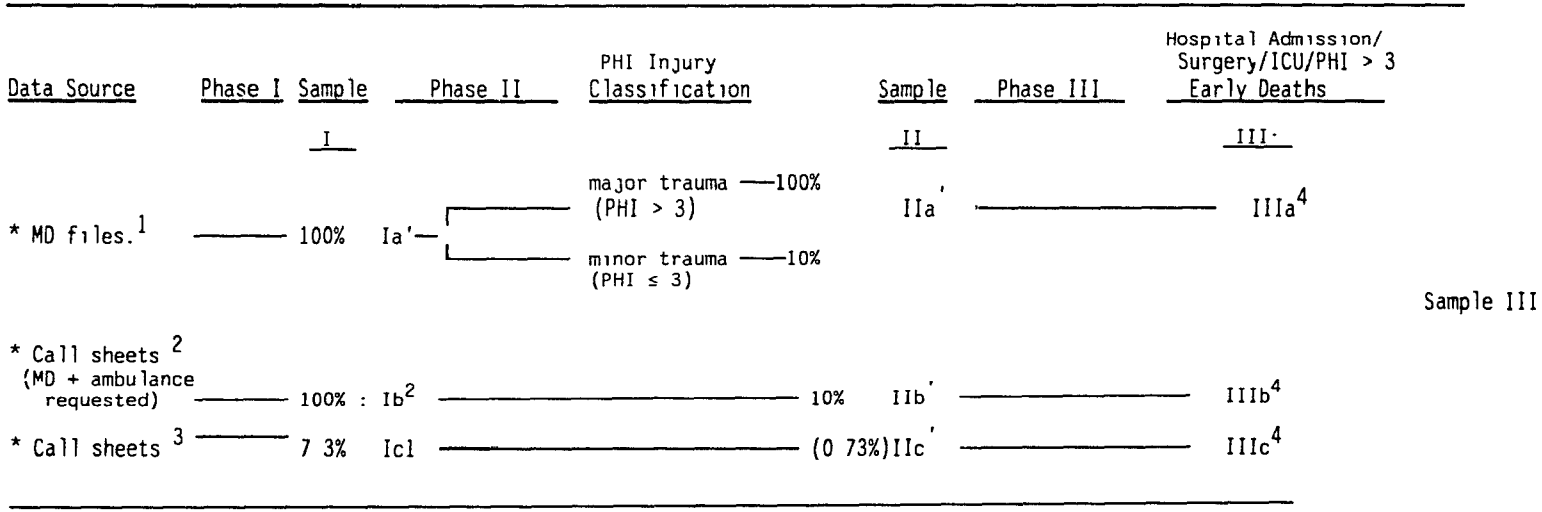


1 With indication of potential trauma

2 With indication of trauma but MD not dispatched

3 With indication of top priority trauma, MD not requested

Figure 3 4 Sampling Scheme Leading to Sample III (Phase I - III)



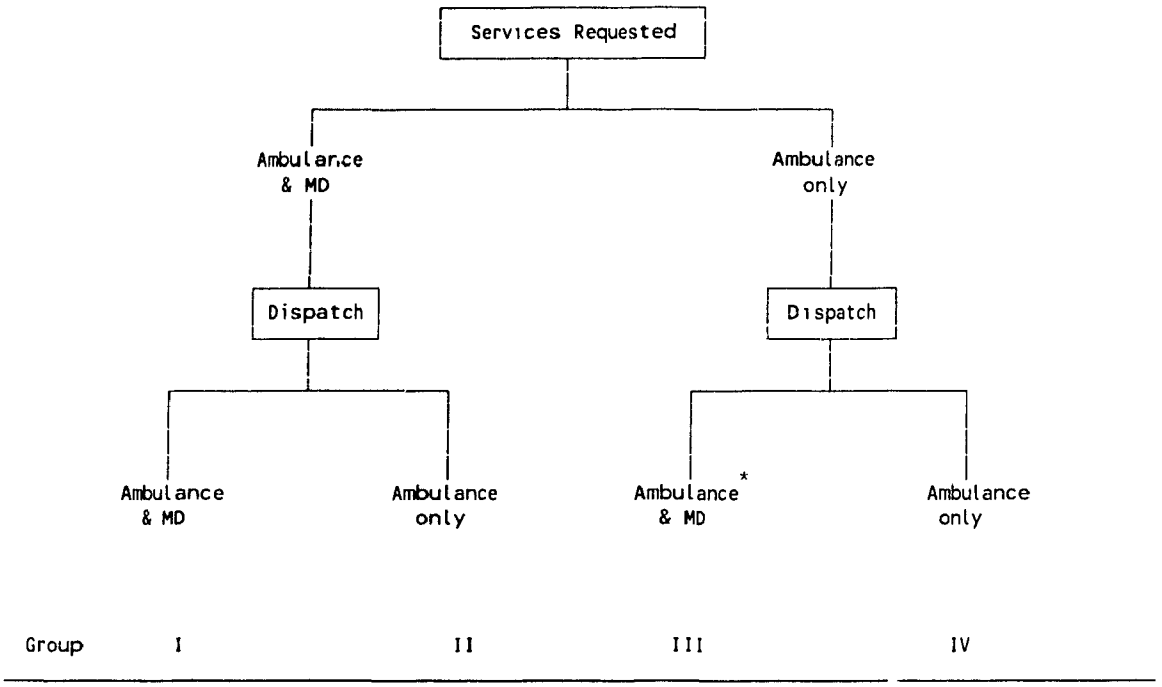
1 With indication of potential trauma

2. With indication of trauma but MD was not dispatched

3 With indication of top priority trauma, MD was not requested

4 Fulfilling criteria for selection.

Figure 3.5 Urgences-Santé Services Requested and Dispatched.



* MD was requested by the EMT after arriving at the scene.

CHAPTER 4. RESULTS

4.1. ASSEMBLY OF STUDY SAMPLE AND SAMPLING

The entire study sampling scheme is depicted in Figure 4.1. Table 4.1 shows the origin of the subjects for the original study sample (Sample I). The review of the Urgences-Santé medical files identified 4722 records for which "trauma" was indicated as the reason for the call to Urgences-Santé. An additional 2308 records for which the nurse at Urgences-Santé requested an MD but for which an MD was not dispatched and a medical record was not retrieved were identified by reviewing the call and dispatch records for the entire period of the study.

The review of a one out of every eighth day sample of the call and dispatch records for which an MD was not requested during the last seven months of the study identified 977 calls classified as "top priority" trauma. This sample of 977 calls represents 7.3% (7/12 months x 1/8 day) of the total number of calls for top priority trauma for which the nurse requested only an ambulance. Under the assumption that the 7-month time period and the days on which the call and dispatch records were sampled are not systematically different than the 5-month period and the days not sampled, the total estimated number of such calls to Urgences-Santé is 13,399 (100 x 977 x 7/12 x 1/8).

The original sample (Sample I) consisted of 8007 (4722 + 2308 + 977) potential trauma victims. Medical records were available for 4722 of these cases and these comprised Sample Ia'; the remaining 3285 patients were treated at the scene by an EMT only and comprised Sample Ib'.

Sample II (N = 928) was derived from the group of 5715 patients in the original sample who were transported to a hospital by an Urgences-Santé ambulance (Figure 4.1). This sample consisted of 337 patients treated by an MD at the scene with a PHI > 3 (Sample IIa'), 10% of the 2928 patients treated by an MD with a PHI < 3 (Sample IIb', N = 287), and 13% of the 2422 patients treated by an EMT only (Sample IIc', N = 304).

Sample III (N = 360) was assembled from patients in sample II fulfilling the inclusion criteria described in Chapter 3, Section 3.3.3.1.. Seventy two subjects were included in the sample because they fulfilled the criteria for definition of a case as the death occurred after the arrival of the ambulance and before seven days from the time of the injury. Of the survivors, 119 were selected because surgery was performed, three because treatment in an ICU was required, 35 because both surgical and ICU care was provided. The remaining referents consisted of 68 patients who were selected because they were admitted into the hospital and 63 surviving patients were selected because they had an on-site PHI > 3. A total of 288 subjects were selected for inclusion in the final sample as referents (Sample III).

4.2. DESCRIPTION OF EMERGENCY MEDICAL SERVICES PROVIDED BY URGENCES-SANTÉ

4.2.1. Services Requested and Provided

The services requested by the Urgences-Sante nurse and the services actually dispatched to the scene for the original sample (Sample I) are summarized in Table 4.2. The nurse requested both an MD and an ambulance for 6207 of the calls. This represents 30.4% of the estimated total 20,429 trauma-related calls to Urgences-Santé during the period of the study. An MD was dispatched to the scene for 4730 (76%) of the 6207 calls for which an MD was requested. For the remaining 1477 (24%) an MD was not available and only an ambulance with an EMT was dispatched.

The nurse requested an ambulance with an EMT for 1800 calls in Sample I. For 823 (46%) of these 1800 patients, an MD was subsequently dispatched to the scene following a request by the EMT. These 823 cases represent 6% of the 13,399 calls for which the nurse requested an ambulance only.

The patients in this sample (Sample I) were classified into four groups according to the type of services requested and dispatched (Chapter 3, Figure 3.5). Group 1 consisted of 4730 patients for whom an MD was requested and was dispatched, Group 2 was comprised of the 1477 patients for whom an MD was originally requested but one was not dispatched. The other two groups consisted of patients for

whom the nurse did not request an MD, Group 3 included the 823 patients for whom the EMT subsequently requested an MD and finally, Group 4 consisted of the 977 patients in this sample for whom an MD was not requested and one was not dispatched.

4.2.2. Receiving Hospitals

Table 4.3 shows the ACS-classification compatibility of the hospitals receiving the 8007 patients included in the original sample. Of the 8007 patients, 1489 (18%) were not transported to a hospital. These 1489 include 312 patients who were dead upon arrival of the MD at the scene. Hospitals which are compatible with ACS-classification level I received 26% of the patients, 20% were transferred to a level II compatible hospital and 36% were taken to hospitals with ACS level III compatible trauma care.

The proportion of patients taken to ACS level I and ACS level II hospitals was similar for the four patient groups, classified according to the services requested and dispatched, as described previously. However, a significantly higher proportion of patients in groups 2 and 4 (EMT only at the scene) were taken to ACS-level III hospitals (groups 2: 53%, group 4: 47%) compared with the patients for whom an MD was dispatched to the scene (group 1: 31%, group 3: 28%), ($X^2 = 312$, $p < 0.001$). The proportion of patients who were not taken to any hospital

was higher for the patients for whom an MD was present at the scene (group 1: 25%, group 3: 31%) compared to the patients for whom only an EMT was dispatched (group 2: 0.5%, group 4: 2%), (X^2 = 696, $p << 0.0001$).

4.2.3. System Times

Table 4.4 presents the system times for the total Sample I (N = 8007) and the four patient groups classified according to the emergency services requested and dispatched. The overall weighted mean response time, defined as the time between the reception of the call at Urgences-Santé and arrival of the ambulance at the scene, was 8.4 minutes with a range of 0 - 177 minutes. The weighted mean transport time for the entire sample was 10.3 minutes with a range of 0-69 minutes. These two time intervals were statistically not different for the four patient groups.

The overall weighted mean time spent at the scene was 19.1 minutes with a range of 0 - 154 minutes. However, when only an EMT was dispatched, the mean time at the scene was significantly lower (group 2: 15.6 ± 8.5 minutes, group 4: 15.3 ± 9.6 minutes) when compared to the scene time when an MD was dispatched (group 1: 20.5 ± 10.5 minutes, group 3: 23.8 ± 14.7 minutes), Tukey's Least Square Difference (LSD) test ($p < 0.05$), Student's t-test, with Bonferroni correction ($p < 0.001$). The mean scene time for the

patients in group 3, i.e. those for whom the EMT subsequently requested an MD was significantly higher compared with the scene time of group 1, i.e. the patients for whom the MD was originally requested and was dispatched to the scene, Tukey's LSD test ($p < 0.05$), Student's t-test with Bonferroni correction ($p < 0.001$). The same significant differences were observed with respect to total pre-hospital time, i.e. the time from call to arrival of the patient at the hospital.

4.2.4. Patients Treated by a Physician at the Scene

4.2.4.1. Demographic Characteristics

Of the 8007 patients in the original sample, 5553 were treated by an MD in the field. For 4722 of these 5553 patients, a medical record was retrieved at Urgences-Santé. These 4722 patients which constituted Sample Ia' included 3913 (83%) patients for whom the MD was originally requested by the nurse and 809 (17%) for whom the EMT requested the MD (Table 4.5).

The demographic characteristics of the patients in Sample Ia' are shown in Table 4.6. The mean age was 37.3 years with a range of 0 - 99 years and a median at 31.0 years. The majority of the patients (64%) were male and young adults between the ages of 16-30 years (36%), 70% were not more than 45 years old. The proportion of male patients was similar (63-69%) for all 15-year interval age groups

with the exception of the > 60 years group in which the proportion of males was 51%.

4.2.4.2. Injury Characteristics, Mechanism of Injury

Table 4.7 shows the distribution of the accident location for the patients that received on-site care by a physician (Sample Ia'). The largest proportion of the accidents were circulation related (MVA), and accounted for 45% of the total. The home and the workplace were the location of 26% and 5% respectively of the accidents in this sample.

Table 4.8 shows the distribution of the mechanisms of injury in this sample. Among the MVA related accidents the majority of the victims (32%) were pedestrians. Drivers of the vehicle constituted 28% of the MVA victims. Falls were the most common non-MVA related cause of accident resulting in 1103 injuries or 23% of the total in this sample. Acts of violence, specifically gunshots, knife stabbings, and fights caused 117 (2%), 193 (4%) and 222 (5%) of the injuries in this sample respectively, thus comprising 11% of the total.

4.2.4.3. Injury Characteristics: Body Regions Involved

The data in Table 4.9 show that for the patients in Sample Ia', the head and neck area, and the extremities were the most commonly injured body regions. Injuries in these body regions respectively occurred in 2681 (57%) and 2184 (46%) of the patients in this sample. The data in this table show that the abdomen was the least frequently injured region, being involved in only 320 (7%) of the patients. However, abdominal injuries had the highest proportion of penetrating trauma (19%) followed by injuries to the chest and extremities in which 13% and 11% respectively were penetrating. Only 5% of the head injuries were penetrating. The majority of the patients (65%) had injuries to only one region and another 23% had two body regions injured. Thus, only 12% of the patients in this sample had injuries to more than two body regions.

4.2.4.4. Injury Characteristics: Severity Pre-hospital Index (PHI)

Complete data required to compute the on-scene Pre-hospital Index, specifically: blood pressure, respiratory rate, pulse and level of consciousness were available for 2800 patients who received on-scene care by a physician (Sample Ia'). The data on the PHI scores for these patients are summarized in table 4.10. The mean PHI score was 3.7 with a median of 0.0 and a range of 0 - 24. Mild

physiological compromise as indicated by a PHI < 3 was observed in 2225 (79.5%) of the patients, moderate physiological damage (PHI: 4 - 8) was observed in 175 (6.2%) of the patients, whereas 400 (14.3%) of the patients suffered severe physiological deterioration as indicated by a PHI > 8. Of the 4722 patients for whom an MD was dispatched to the scene, 312 (6.6%) were dead when the physician arrived.

4.2.4.5. On-site Care Provided by Physicians

Table 4.11 summarizes the on-site care provided by physicians to the patients in Sample Ia'. Of the Basic Life Support procedures, the most commonly used was immobilization of the spine and head which was performed on 34.3% of the patients. Wound dressing and oxygen administration was performed on 17.7% and 13.6% of the patients respectively. Only 79 (1.7%) of the patients in this sample required extrication.

Initiation of an I.V. line was the most commonly performed Advanced Life Support procedure, and was used in 1218 (25.8%) of the patients. Medications were administered to 346 (7.3%) of patients and 160 (3.4%) were intubated. Finally, the PASG were applied in only 44 (0.9%) of these patients.

The data in Table 4.11 also show that ALS procedures were performed by the physicians in 1343 (28.4%) of the patients in this sample. For the remaining 3379 (71.6%) only BLS was provided.

Table 4.12 shows the mean Pre-hospital Index score and mean scene time by the level of on-site care received for the patients in sample Ia'. These data show that the physiological status of the patients receiving ALS care was significantly worse (PHI: mean ± 1 s.d. = 3.5 ± 6.6; PHI > 3: 24%) when compared to the patients for whom only BLS procedures were performed (PHI: mean ± 1 s.d. = 0.4 ± 1.3; PHI > 3: 3%) and when compared with the patients for which no on-site procedures were performed (PHI: mean ± 1 s.d. = 0.6 ± 1.3; PHI > 3: 4%). In addition, as the mean PHI and the proportion of patients with moderate to severe trauma (PHI>3) increased the number of ALS procedures performed increased significantly (Tukey's LSD: $p < 0.05$, Student's t-test, $p < 0.001$ with Bonferroni correction).

The mean scene time was significantly higher for the patients receiving ALS (24.3 ± 11.2 minutes) when compared with the patients receiving only BLS (19.7 ± 10.1 minutes) and with those for which no procedures were performed (20.5 ± 11.6 minutes). In addition, the mean scene time was higher in those patients for whom an increasing number of on-scene ALS procedures performed. These differences were statistically significant by the F ratio for Analysis of

Variance (ANOVA) ($F = 427.3$, $p < 0.0001$), as well as Tukey's Least Significant difference and Student's t-test using Bonferonni correction for multiple pairwise comparisons (Tukey's LSD: $p < 0.05$, Student's t-test, $p < 0.001$ with Bonferroni correction).

Table 4.13 summarizes the results of a multivariate linear regression analysis evaluating the association between the level of on-site care and mean scene time while controlling for PHI scores. In this analysis, scene time and PHI were entered as continuous variables and the level of on-site care was entered as a categorical ordinal variable of a range from 0 - 5 with 0 representing no on-site procedures and 5 representing four ALS procedures. The results of this analysis show that on-site care is significantly linearly associated with scene time ($p = 0.001$) while controlling for PHI scores.

4.2.5. Patients Followed to the Hospital

As was mentioned in Section 4.1, of the patients treated by a physician 100% of those with a PHI > 3, and random 10% sample of those with a PHI < 3 were followed to the hospital. A random 13% sample of the patients not treated by a physician was also included in the sample that was followed to the hospital. Table 4.14 presents the data on the in-hospital treatment provided to these patients. These data show that 183 (20%) required surgery, 158 (17%)

required treatment in an ICU, and 81 (8%) required surgery and were admitted in an ICU. For those treated in an ICU, the mean duration of stay in such a facility was 101.5 hours, with a median of 48.0 hours and a range of 0-999 hours.

The outcome of the patients followed to the hospital is shown in table 4.15. There were 117 fatalities among the 928 patients followed to the hospital for an overall mortality rate of 13%. The majority of the deaths, (64, 55%) occurred within 24 hours from the time of the injury, 27 of which occurred before the arrival of the ambulance. There were 15 late deaths, i.e. occurring more than seven days from the time of the injury that accounted for 11% of the total fatalities. Over 80% of the deaths occurred within three days from the day of the injury. Among the 811 survivors, 788 (97%) were discharged alive and 23 were transferred to a long-term care facility.

4.3. DESCRIPTION AND ESTIMATION OF THE IMPACT OF EMERGENCY MEDICAL SERVICES ON TRAUMA MORTALITY IN MONTREAL

4.3.1. Description of Study Sample

The selection process and rationale leading to the third study sample were discussed in Sections 3.2.4 and were described in Figure 4.1. In summary, the objective for selecting patients to be included in this sample was to define the appropriate study subjects for the evaluation of emergency pre-hospital care using a case-referent design. The cases were selected from the 117 fatalities in Sample II. The 27 deaths which occurred before the arrival of the ambulance were excluded because they were considered as immediate deaths. As was mentioned in Chapter 1, these deaths are generally caused by fatal injuries and are not preventable regardless of the level of medical care. Among the 90 deaths which occurred after the arrival of the ambulance, three were caused by fatal injuries which were not compatible with life (AIS = 6, ISS = 75), and were excluded.

The remaining 87 patients who died were included in Sample III; however 15 of these died after six days from the time of the injury. These were considered as late deaths as was discussed in Chapter 1 are not affected by the quality of pre-hospital or emergency care. These were therefore considered as referents. The remaining 72 fatalities were considered as early deaths, i.e. occurring after 1-2 hours

and before one week from the time of the injury. These comprised the cases for the case-referent study.

Table 4.16 shows the demographic characteristics of the patients in this sample. The mean (± 1 s.d.) age was 33.9 ± 19.4 with a range of 0 - 84 and a median of 29.0 years. The majority of the patients in this sample were male (71%) and 40% were between the ages of 16 and 30 years. The proportion of males was lowest for the 0 - 15 years and > 60 years age groups, 53% and 55% respectively. The proportion of male patients was highest for the 16 - 30 years and 31 - 45 years age groups, 80% and 76% respectively.

Data on pre-existing conditions shown in this table indicate that the most commonly observed conditions were pulmonary, which were present in 19 (5%) of the patients, followed by cardiovascular conditions and diabetes which were present in 9 (3%) and 8 (2%) of the patients respectively. There were 44 (12%) patients in this sample with at least one pre-existing condition from the following categories: cardiovascular, renal, pulmonary, diabetes, cirrhosis, cancer.

4.3.2. Comparisons with Standard Populations

Table 4.17 shows the expected number of deaths according to the four standard populations described in Section 3.3.2. There were 72 (20%) deaths in this sample (N = 360) and 42 (40%) in the group of 103 patients for which an on-site TS was available. The expected number of deaths by applying Bull's (1974) probit equation was 41.85 (12%); this resulted in an observed to expected (O/E) ratio of deaths of 1.72, and a highly significantly difference between expected and observed number of deaths ($Z = 7.09$, $p < 0.0001$). Applying the logistic regression equation reported by McLellan, the expected number of deaths of 19.51 (5%) was highly significantly lower than the 72 deaths observed, ($Z = 23.77$, $p < 0.0001$).

According to the probabilities of survival published by Copes et al. (1988) for specific age groups, type of injuries and ISS scores obtained from data on patients in the Major Trauma Outcome Study, the expected number of deaths was 38.99 (11%). The O/E ratio for this standard was 1.85 and the difference between expected and observed mortality was statistically significant ($Z = 6.77$, $p < 0.0001$). Finally, applying the logistic regression coefficients published by Boyd et al. (1987) for determining the probability of death according to the patient's age, type of injury (blunt vs. penetrating), TS and ISS (TRISS), resulted in 24.14 (23%) expected deaths for the subsample of

103 patients with available TS scores. The 42 (40%) observed deaths in this subsample was significantly higher than the number expected ($Z = 4.14$, $p < 0.0001$), and the O/E ratio was 1.74.

4.3.3. Description and Estimation of the Impact of Emergency Medical Services Components on Trauma Mortality in Montreal

This objective was addressed by comparing the observed to expected mortality for various groups of patients classified according to the level of pre-hospital care, ACS-compatibility of the receiving hospital and the total pre-hospital time. The standard population used in these analyses was the MTOS as described by Copes et al. (1988). The rationale for deciding to use this population was presented in Section 3.3.2.

The data presented in Table 4.18 show that for the group of 47 patients that were treated by an EMT only, at the scene, the 1.6 (3%) expected deaths were not significantly different from the 2 (4%) observed ($Z = 0.34$, $p = 0.73$). The O/E ratio for this group was 1.25. There were 2 (5%) observed fatalities compared to the 1.6 expected among the 37 patients for whom an MD was dispatched but no on scene interventions were performed. For this group of patients the O/E ratio was 1.25 and the difference between observed and expected mortality was not significant ($Z =$

0.40, $p = 0.69$). For the 37 patients who received only BLS by the physician there were 4 (11%) observed and 1.4 (4%) expected deaths resulting in an O/E ratio of 2.86. The observed and expected mortality was significantly different for these patients ($Z = 2.52$, $p = 0.01$). When the last three groups of patients are considered collectively as one group (BLS only, N = 121), the expected 4.6 (4%) deaths were not significantly higher than the 8 (7%) observed ($Z = 1.83$, $p = 0.07$). Finally, in the 239 patients receiving ALS treatment by the physician there were 64 (27%) observed deaths compared to the 37.2 (16%) expected ($Z = 6.54$, $p < 0.0001$).

The X^2 analyses failed to show significant difference with respect to the differences in expected and observed mortality between these four patient groups ($X_3^2 = 1.86$, $p = 0.6$), or between the two groups classified as BLS (no procedures, EMT only, BLS only), and as ALS ($X_1^2 = 0.05$, $p = 0.82$). In addition the X^2 test for trend using the four group classification was not significant ($X_1^2 = 0.14$, $p = 0.71$).

Table 4.19 shows the data on observed and expected deaths by the ACS-classification compatibility of the receiving hospital. These data show that for all hospital levels the number of the deaths observed was significantly higher than the expected deaths. However, the highest O/E ratio was observed for level III compatible hospitals (O/E = 2.26). The Chi-square analyses for differences in the O/E

ratio between groups was not significant (X^2 = 1.93, p = 0.38). However, a statistically significant trend was detected for an increasing O/E ratio with decreasing level of trauma care available at the receiving hospital, i.e. from ACS-I to ACS-III compatible (X_1^2 = 4.33, p = 0.037).

The data in Table 4.20 show the observed and expected deaths for groups of patients classified according to the total pre-hospital time. These data show that the difference between observed and expected deaths becomes significantly higher for delays greater than 15 minutes with the highest O/E ratio and difference between observed and expected deaths occurring in the patient group with pre-hospital times greater than 60 minutes. The Chi-square test for trend in O/E ratios by increasing time to hospitalization using 15-minute interval categories was not statistically significant (X_1^2 = 0.31, p = 0.58).

Table 4.21 summarizes the results of a multivariate logistic regression predicting standardized odds of dying incorporating external rates as determined by indirect standardization to the MTOS. The results of this analysis demonstrate that delay to hospitalization exceeding 60 minutes is significantly associated with and increase in the standardized odds ratio of dying (OR = 95% CI = 2.7 - 33.3). The use of on-site ALS was not associated with a decrease in the odds of death, in excess to that predicted by indirect standardization to the MTOS (OR = 1.4, 95% CI = 0.4 - 4.2). Treatment in an ACS-level I or II compatible hospital was associated with a decrease in the standardized

odds of dying (OR = 0.7, 95% CI = 0.4 - 1.21).

4.4. ESTIMATION OF THE EFFECTIVENESS OF ALS IN REDUCING TRAUMA-RELATED MORTALITY

This section focuses on the case-referent study described in Section 3.3.3.1. Because the cases and referents were not matched with respect to important prognostic variables and the allocation of treatment was not random potential confounding should be examined in detail. The sequence of the analyses was aimed at first identifying significant differences between cases and referents and between the two treatment groups, i.e. ALS and BLS with respect to important prognostic variables. This process would identify any potential confounders.

The next stage of the analysis estimated the crude relative odds of dying (being a case) associated with being treated by ALS. Stratified analysis was then carried out to assess the significance of any confounding and to identify potential effect modifiers. The final phase of the analyses focuses on testing several logistic regression models of increasing complexity that were designed to evaluate the effect of on-site ALS on the probability of death while controlling for prognostic variables. The results of these analyses will be presented in the following sections.

As was mentioned in Section 4.1, a total of 360 patients were included in Sample III which were used in this analysis. Of these patients, 72 (20%) fulfilled the

criteria of a case and 288 (80%) fulfilled the criteria of a referent.

The definition of a case in this study indicates death after arrival of the ambulance and before seven days from the time of the accident. Throughout the remainder of the section, odds of dying and odds of being a case are used interchangeably. In addition, when reference is made to statistical significance of odds ratios or relative odds it implies difference from unity. In addition, when the term "risk" is used it implies odds and consequently "relative risk" is used interchangeably with "relative odds". This is merely an editorial or stylistic use of these two terms and does not imply that the number of deaths in this study is sufficiently small to justify equating odds with risk.

4.4.1. Comparison of Cases and Referents

4.4.1.1. Demographic Characteristics

Table 4.22 shows the age and gender characteristics of the cases and referents. These data show that the cases and referents were similar with respect to mean and median age values ($t = 1.35$, $p = 0.25$). Similarly, the age distribution by 15-year intervals was not statistically significantly different; however, a higher proportion of referents was over 60 year old (21%) when compared to the cases (10%). In addition, the proportion of males in the 0 - 15 years age group was higher for the cases (62%) when

compared to the referents (33%). These differences approached statistical significance ($X^2_4 = 9.13$, $p = 0.06$).

The data in Table 4.23 show the distribution of pre-existing conditions (PEC) for the cases and referents. Increased odds of being a case were associated with the presence of cardiovascular (OR = 3.3, 95% CI = 0.9 - 11.8) and pulmonary disease (OR = 2.5, 95% CI = 1.0 - 6.4) conditions although the 95% CI of the OR for cardiovascular conditions comprised unity and only approached statistical significance. The odds ratio of being a case associated with having any of the conditions was statistically significant with a point estimate of 2.6 and 95% CI between 1.4 and 5.1.

4.4.1.2. Injury Characteristics

The data in Table 4.24 show that a significantly increased risk of dying was associated with being involved in a motor-vehicle accident, (OR = 3.6, 95% CI = 2.1 - 6.1). Conversely, the odds ratio of being a case associated with accidents at the home was significantly lower than unity (OR = 0.3, 95% CI = 0.14 - 0.63) and accidents in the workplace were non-significantly associated with a reduced risk of dying (OR = 0.15, 95% CI = 0.01 - 1.73). The Chi-square analysis shows that the distribution of the accident location was significantly different for the cases and referents ($X_4^2 = 31.7$, $p < 0.001$).

Table 4.25 summarizes the distribution of the mechanism of injury for cases and referents. The data indicate that significantly increased odds of dying were associated with injuries caused by firearms (OR = 3.1, 95% CI = 1.3 - 7.8), with being involved in a motorcycle accident (OR = 4.3, 95% CI = 1.6 - 11.8) and being a pedestrian struck by an automobile (OR = 2.7, 95% CI = 1.5, 4.9).

Hanging (OR = 3.0, 95% CI = 0.7 - 13.1), or being a driver (OR = 1.6, 95% CI = 0.6 - 4.0), a passenger (OR = 2.1, 95% CI = 0.6 - 6.9), or a bicycle rider (OR = 1.3, 95% CI = 0.4 - 5.1) involved in an MVA were associated with a non-significant increase in the risk of dying. Overall, the distribution of mechanism of injury were significantly different between cases and referents (X_{12}^2 = 36.8, $\underline{p}$ = 0.002).

The body regions injured for the cases and referents are shown in Table 4.26. Head injures, either isolated (OR = 2.8, 95% CI = 1.2 - 6.7) or in combination with injuries to other body regions (OR = 9.3, 95% CI = 5.0 - 17.1) were associated with an increased odds of dying. Similarly, the presence of a chest or an abdominal injury were also significantly associated with an increased risk of dying (chest: OR = 3.9, 95% CI = 2.3 - 6.8), abdominal (OR = 1.9, 95% CI = 1.1 - 3.3).

The odds ratio of dying associated with having injuries to more than one body region was statistically significant

(OR = 4.4, 95% CI = 2.4 - 8.2). A significantly higher proportion of cases had three to five body regions injured (X_4^2 = 51.6, $p < 0.0001$).

The presence of penetrating trauma was associated with a significantly decreased odds of dying (OR = 0.3, 95% CI = 0.1 - 0.7).

The data in Table 4.27 show that, the cases were more severely injured when compared to the referents in this sample. The mean (1 ± s.d.) ISS of the cases was 29.0 ± 11.3 with a range of 5 - 59 and a median of 27. For the referents, the mean (± 1 s.d.) ISS was 9.9 ± 9.0, the median was 9.0 and the range was 1 - 43. The difference with respect to the mean ISS scores between these two groups was statistically significant ($t = 13.4$, $p \leq 0.0001$).

Similarly, the differences in TS between cases and referents indicate that the physiological damage at the time the physicians arrived at the scene was more severe in the cases compared to the referents. The mean (± 1 s.d.) of the 38 cases for which a TS was obtained, was 9.3 ± 3.9 with a median of 10.5 and a range of 1 - 16. Trauma scores were available for 65 referents, in this group the mean (± 1 s.d.) was 12.7 ± 3.0, with a median of 13.0 and a range of 4 - 16. The difference in the mean TS between case and referents was statistically significant ($t = 4.6$, $p \leq 0.0001$).

4.4.1.3. Emergency Medical Services

The data in Table 4.28 summarize on the system times, specifically response, scene, transport and total time for the cases and referents. The data in this table show that the means of all system times were similar for the cases and referents although the mean scene time and total time was slightly longer for the cases (cases: scene: 21.2 ± 10.3 minutes, total: 37.1 ± 17.1 minutes, referents: scene:19.8 ± 10.4, total: 35.2 ± 14.9 minutes). These differences, however are not clinically or statistically significant. The data in Table 4.29 confirm this finding showing that the distribution of the pre-hospital times was similar for the cases and referents. These data also show that a non-significant increase in the odds of dying was associated with total delays to hospitalization of 30 minutes (OR = 1.4, 95% CI = 0.7 - 2.7) and of 60 minutes (OR = 2.0, 95% CI = 0.7 -6.8).

Table 4.30 describes the on-site care provided to the cases and referents. These data show that on-site ALS was used significantly more for the cases when compared to the referents (OR = 8.2, 95% CI = 2.4 - 28.20). These data also show that the distribution of the type of on-site care was significantly different for the cases and referents (X_3^2 = 21.02, $p < 0.001$).

The proportion of cases and referents transported to level I compatible hospitals was similar (cases: 43%, referents: 44%). However, a higher proportion of referents were transported to a level III compatible hospital (cases: 19%, referents: 27%) and the converse was true for level II compatible hospitals (cases: 38%, referents: 29%). The distributions of the ACS-compatibility of the receiving hospital for the cases and referents was not significantly different (X_2^2 = 2.9, p = 0.225) (Table 4.31).

4.4.2. Comparison of Treatment Groups

Of the 360 patients in Sample III, 239 received ALS at the scene and the remaining 121 received only BLS. The results of comparing the two treatment groups on predictor variables are presented in the tables in Appendix A. These analyses show that the two treatment groups were similar with respect to age and the presence of pre-existing conditions (Tables A1, A2). The proportion of MVA injuries was higher for patients in the ALS group (46%) compared to the patients in the BLS group (19%) (OR = 3.5, 95% CI = 2.1 - 4.8) (Table A.3).

The two treatment groups were significantly different with respect to the proportion of injuries caused by firearm (ALS: 7%, BLS: 1%; OR = 9.8, 95% CI, 1.9 - 5.2), laceration (ALS: 8%, BLS: 4%; OR = 2.1, 95% CI = 8.8 - 5.7), fights (ALS: 0.4%, BLS: 3%; OR = 0.1, 95% CI = 0.02 - 0.80). Among

the MVA injuries, a higher proportion of ALS patients were drivers (ALS: 10%, BLS: 2%; OR= 6.3, 95% CI = 1.7 - 22.9), passengers (ALS: 15%, BLS: 0%; OR = 12.7, 95% CI = 1.4 - 116.30, and pedestrians (ALS: 20%, BLS 11%; OR = 2.2, 95% CI = 1.1 - 4.1) (Table A.4).

Significant differences between the two treatment groups were also observed with respect to the body regions injured. A higher proportion of ALS patients had isolated head (ALS: 9%, BLS: 2%; OR = 5.7, 95% CI = 1.3 - 24), head (ALS: 45%, BLS: 22%; OR = 2.9, 95% CI = 1.7 - 4.7), chest (ALS: 35%, BLS: 18%; OR = 2.4, 95% CI = 1.4 - 4.1) and abdominal (ALS: 29%, BLS: 14%; OR = 2.6, 95% CI = 1.4 - 4.6) injuries when compared to the BLS patients (Table A.5). The data Table A.6 show that the patients in the ALS group had more severe injuries when compared to the patients in the BLS group as indicated by the significantly higher mean ISS scores (ALS: 16.7 ± 13.0, BLS: 7.9 ± 7.7; t = 6.8, p = 0.0001) and significantly lower mean TS (ALS: 10.8 ± 3.7, BLS: 14.5 ± 1.9; t = 6.1, p = 0.0001).

Tables A.7 show that the mean time spent on scene and the mean total time were significantly higher for the patients in the ALS group (scene time:(mins.); ALS: 22.1 ± 9.4; BLS: 16.2 ± 10.9; t = 4.8, p = 0.001); (mean ± 1 s.d.) total time: ALS: 38.2 ± 13.9; BLS: 31.1 ± 16.6; t = 3.6, p = 0.004). A higher proportion of patients in the ALS groups had pre-hospitalization times exceeding 60 minutes when

compared to the BLS group (ALS: 75%, BLS: 52%, OR = 2.8, 95% CI, 1.7 - 4.6 (Table A.8).

Finally, the data in Table A.9 show that a higher proportion of patients in the BLS group were transported to ACS level III compatible hospital when compared to the patients in the ALS group (BLS: 36%, ALS: 21%). Conversely, a higher proportion of patients in the ALS group were transported to level II compatible hospitals when compared to the patients in the BLS group (ALS: 3%, BLS: 25%) (X_2^2 = 10.7, p = 0.005).

In summary these results show that the two treatment groups differ significantly with respect to injury characteristics, body regions injured and injury severity as well as the total pre-hospital time.

4.4.2.1. Estimation of Association Between ALS and Risk of Dying

4.4.2.1.1. Univariate and Bivariate Analyses

The unadjusted odds ratio of being a case associated with ALS treatment was 5.17 with a 95% CI of 2.39 - 11.8 (Table 4.32). This finding suggests that treatment with ALS significantly increases the risk of death for the patients in this sample. However, the analyses in the previous section have revealed that there were significant differences between the cases and referents with respect to important prognostic variables including injury severity,

mechanism of injury and body regions injured. Similarly, significant differences with respect to these factors were also detected between the two treatment groups. Because significant associations were detected between prognostic variables and both the treatment and the outcome variables, the observed associations of ALS with the odds of dying may be due to confounding, especially with respect to injury severity.

Stratified analyses were carried out to estimate the association of being treated by ALS and being a case while adjusting for potential confounding variables. The results of these analyses are presented in Appendix B and are summarized in Table 4.33.

Although there were no statistically significant differences with respect to the odds ratio of dying associated with ALS treatment between specific strata of the prognostic variables tested, the following observations are worth mentioning. The odds ratio for the 16-30 age group was significant (OR = 13.4, 95% CI: 1.8 - 102.9), whereas the odds ratios for the other age strata were lower and not significantly different than unity.

For all body regions tested, the odds ratio of dying associated with treatment by ALS, decreased as the severity of the injury increased. Specifically, the odds ratio were lower for the region specific AIS: 4 - 5 stratum, compared to the AIS 1 -3 stratum (Tables B.5 - B.8). For head

injuries, the odds ratio in the AIS 1 - 3 stratum was 2.8 (95% CI = 0.3 - 26.0) compared to the AIS 4 - 5 stratum odds ratio of 1.0 (0.3 - 4.7). Similarly, the odds ratio for patients with severe chest injuries was 3.4 (95% CI = 0.3 - 44.0) compared to 11.5 (95% CI = 1.5 - 91.9) for patients with minor chest injuries (AIS: 1 - 3). The odds ratio for patients with severe abdominal injuries was also lower than that for minor abdominal injuries (AIS: 1 - 3; OR = 13.6, 95% CI = 1.4 - 133.3); (AIS: 4 - 5; OR = 1.0, 95% CI = 0.5 - 20.8). Similar decreases in the odds ratio were observed for stratification by single/multiple region and blunt / penetrating trauma (Tables B.9, B.10), and by stratification by ISS categories (Table B.11.). The data in this table show that in fact the point estimate of the odds ratio for patients with ISS scores above 24 indicates a non-significant decreased odds of dying associated with ALS (OR = 0.7, 95% CI = 0.1 - 3.7).

The importance of pre-hospital time is demonstrated by the higher odds ratio for dying associated with ALS for pre-hospital times between 31 - 60 minutes (OR = 15.8, 95% CI = 2.1 - 12.0) and for patients with delays to hospital arrival over 60 minutes (OR = 10.0, 95% CI = 0.5 - 199.6). The odds ratio for the patients who were brought to the hospital within 30 minutes was 2.3 (95% CI = 0.7 - 7.4).

The data in Table 4.33 show the odds ratio of dying associated with ALS treatment adjusted for ISS (Adjusted OR = 1.6, 95% CI = 0.6 - 4.3) and the presence of head injuries (Adjusted OR = 2.8, 95% I = 1.1 - 6.7) was considerably, although not statistically significantly, lower than the crude odds ratio of 5.2. These results suggest potential confounding with respect to injury severity (ISS) which may be partially causing the observed increases odds of dying associated with ALS treatment. However, even after adjusting for these variables, ALS failed to demonstrate an association with decreased odds of dying.

4.4.2.1.2. Multivariate Analyses

A series of logistic regression models of increasing complexity were tested to evaluate the adjusted effect of ALS on the odds of dying while controlling for other variables. The results of these analyses are presented in Appendix C.

The first model (Model I, Table C.1) focused on assessing the impact of ALS on the probability of dying while controlling for patient characteristics, injury type, injury severity, and body regions injured. In this model, the only variable with a statistically significant coefficient was ISS (OR = 4.78, 95% CI = 2.95 - 7.75). Among the other variables, increasing age was non-significantly associated with increasing odds of dying (OR =

1.01, 95% CI = 0.99 - 1.03). Being injured in an MVA was also associated with a non-significant increased odds of dying (OR = 1.39, 95% CI = 0.88 - 2.18). The use of on-site ALS was not significantly associated with the odds of dying, although the sign of the coefficient indicated a positive association (OR = 1.07, 95% CI = 0.64 - 1.74). The results from this model failed to demonstrate any impact of ALS on reducing the probability of death.

The second model was a modification of the first model with an addition of an ISS x ALS interaction term (Table C.2.). The sign of the coefficient for this interaction was negative indicating that the association between ALS and the probability of dying, becomes more negative as ISS increases. The estimate of the interaction coefficient however was not statistically significant (OR = -0.760).

Model III included the same variables as Model I with the substitution of the ISS score with the individual AIS score of the six body regions included in the calculations of the ISS and the exclusion of variables representing body regions injured. These results showed an increased odds of death associated with increasing severity of injuries to the head (OR = 2.30, 95% CI = 1.80 - 2.94), chest (OR = 1.80, 95% CI = 1.38 - 2.34) and the abdomen (OR = 1.80, 95% CI = 1.27 - 2.54).

Model IV included all the Model I variables and variables representing mechanisms of injury which were found to be significantly associated with risk of death by the bivariate analyses. Specifically, variables indicating domestic accidents, the involvement of gunshot wounds, stabbings, and lacerations as causes of injury. The variable representing an MVA was replaced by variables indicating that the victim was a driver, pedestrian or motorcycle rider involved in an MVA. The results from this model showed that gunshot injuries were significantly associated with increased risk of dying (OR = 2.66, 95% CI = 1.24 - 5.71). Being a rider of motorcycle involved in an MVA was associated with a non-significant increased odds of dying (OR = 1.88, 95% CI = 0.83 - 4.28).

The final model tested (Model V, Table C.5) included variables representing the ACS-classification compatibility of the receiving hospital and the pre-hospital time. This model demonstrated that a decrease in the odds of dying was associated with being transferred to an ACS-level I compatible hospital, compared to ACS-level III compatible facilities (OR = 0.68, 95% CI = 0.37 - 1.23). In this model, total pre-hospital time exceeding 60 minutes was significantly associated with an increased odds of dying (OR = 3.04, 95% CI = 1.28 - 7.27). These results suggest a three-fold increase in the risk of dying associated with delaying hospital transport by more than 60 minutes.

In summary, the consistent finding of these analyses is that of a non-significant association between treatment with on-site ALS and odds of dying. Of the remaining independent variables, gunshot injuries and delay to hospitalization exceeding 60 minutes were significantly associated with an increased odds of death.

Table 4.34 shows the results of a stepwise logistic regression analyses using all the variables tested in Models I-IV. The four variables that fulfilled the entry criterion of $p = 0.10$ and the remove criterion of $p = 0.15$ were age, involvement in an MVA, time to hospitalization, gunshot injuries, ISS, and ACS classification of the receiving hospital. Of these, the following were significantly associated with an increased risk of dying: involvement in an MVA (OR = 1.63, 95% CI = 1.17 - 2.39), delay to hospitalization exceeding 60 minutes (OR = 3.00, 95% CI = 1.23 - 7.33) and gunshot injuries (OR = 2.42, 95% CI = 1.22 - 4.79).

In this model, being transferred to an ACS-compatible level I hospital was associated with a reduction in the odds of dying when compared to being transferred to an ACS level III compatible hospital (OR = 0.69, 95% CI = 0.43 - 1.15). When the variable representing ALS treatment was forced into the final stepwise selected model, its coefficient failed to demonstrate a significant association with the odds of dying (OR = 1.08, 95% CI = 0.64 - 1.83). In this model, treatment

at an ACS level I compatible hospital was again associated with a reduced relative odds when compared to treatment in an ACS level III compatible hospital (OR = 0.62, 95% CI = 0.34 - 1.12). The coefficient for this variable approached statistical significance (p = 0.055, one tail).

Multicollinearity and Goodness of Fit

Multicollinearity in the final stepwise selected logistic model was evaluated by assessing the correlation between the logistic regression coefficients. The coefficient correlation matrix shown in Appendix D (Table D.1 indicates that the highest correlation occurred between ISS and time to hospitalization (r = 0.368). Since this correlation coefficient is below 0.70, severe multicollinearity among the variables in this model was not present. Similarly, absence of severe multicollinearity was observed for the final model with ALS and ACS-classification compatibility included (Appendix D, Table D.2).

The Goodness of Fit Chi-Square for all logistic models was not significant, indicating adequate fit.

Table 4.1. Assembly of Original Sample

Source	N
1) Review all Medical Charts at Urgences-Santé Select all trauma cases.	4,722
2) Review all Call and Dispatch records at Urgences-Santé Select all trauma cases for which nurse requested AMB and MD.	2,308[a]
3) Review all Call and Dispatch records at Urgences-Santé on every 8th day for last 7 months Select Top Priority Trauma, MD not requested	977[b]
TOTAL	8,007

a Medical files were not located for these patients.

b Represents 7.3% (7/12 * 1/8) of total cases for which MD was not requested by nurse, estimated total = 13,399

--- Total estimated calls to Urgences-Santé for potential trauma

13,399 + 2,308 + 4,722 = 20,429

Table 4 2 Emergency Medical Services Provided by Urgences-Santé

Urgences-Santé Services.

Requested	N (%)	Dispatched	N	(%), [%]
EMT + MD	6207 (78)	EMT + MD	4730	(59) [76]
		EMT	1477	(18) [24]
EMT	1800 (22)	EMT + MD	823	(10) [46] {6}
		EMT	977[1]	(13) [54] {94}
TOTAL	8007			

1 Represents only 7 3% of the total calls for which the nurse requested only an EMT and only an EMT was dispatched

Estimated total N = 13,399 calls during the 12-month period for whom an MD was not requested by the nurse and only an EMT was dispatched

Total estimated requests for EMT only· N = 13,392 + 823 = 14,215

(Percent of Total Sample)
[Percent of Request Category]
{Percent of Estimated Total calls for whom an EMT only was requested}

Table 4 3 American College of Surgeons (ACS) Classification Compatibility of Receiving Hospital by Urgences-Santé Services

Receiving Hospital ACS-Classification Compatibility	Urgences-Santé Services (Group) N (%) Request: EMT + MD — Dispatch: (1) EMT + MD	Request: EMT + MD — Dispatch: (2) EMT	Request: EMT — Dispatch: (3) EMT + MD	Request: EMT — Dispatch: (4) EMT	Total
I (7)	1173 (25)	390 (26)	192 (23)	295 (30)	2050 (26)
II (4)	921 (19)	299 (20)	148 (18)	198 (20)	1566 (20)
III (22)	1435 (31)	780 (53)	227 (28)*	460 (47)	2902 (36)
None --	1201 (25)	8 (0 5)	256 (31)	24 (2)	1489 (18)
Total	4730	1477	823	977	8007

* Includes 312 patients who were dead upon arrival of the physician

Table 4 4 System Times by Urgences-Santé Service Provided (Sample I, N = 8007).

Urgences-Santé Service				System Time Intervals (min) mean ± 1.S.D [Range]			
Group	Request	Dispatch	N	Response	Scene	Transport	Total
1)	EMT + MD	EMT + MD	4286	8 0 ± 4 7 [0-87]	20 5 ± 10 5[2] [0-101]	9 4 ± 6.9 [0-69]	38 1 ± 13 6[2] [6-106]
2)	EMT + MD	EMT	1435	8 4 ± 5 6 [0-67]	15 6 ± 8 5 [0-63]	9 9 ± 7 4 [0-63]	33.8 ± 12 8 [8-92]
3)	EMT	EMT + MD	589	8 7 ± 6 4 [0-68]	23 8 ± 14 7[2,3] [1-130]	9 4 ± 8 8 [0-66]	44 8 ± 20 4[2,3] [10-199]
4)	EMT	EMT	942	8 2 ± 4.4 [1-42]	15 3 ± 9 6 [0-154]	10 7 ± 8 0 [0-58]	34.2 ± 13 2 [10-170]
	Total	---	7252*	8 2 ± 5 8 [0-87]	18 8 ± 10 8 [0-154]	9 7 ± 7 4 [0-69]	36 9 ± 14 3 [6-199]
	Weighted Mean			8 4	19.1	10 3	37 8
F^1		---	---	59.6	139 6	7 8	76 6
p^1		---	---	0 0001	0 0001	0 0001	0.0001

* Data were missing on time intervals for 755 calls

1 Based on One Way Analysis of Variance
Tukey's Least Significant Square Difference for pairwise comparison ($p < 0\ 05$) for
2 comparison with EMT only dispatched (groups 2,4)**
3 comparison with EMT only dispatched (groups 2,4)** and
EMT and MD requested and dispatched (group 3)

** Differences significant ($p < 0\ 01$) using Student's t-test and Bonferroni inequality correction for the number of comparisons

System Times,

Response	Time of call to arrival of ambulance at the scene
Scene	Time at scene (arrival to departure of ambulance)
Transport	Time of departure from the scene to arrival at hospital

Table 4 5 Urgences-Santé Medical Records.

	Total	Medical Records Retrieved
MD requested by nurse	4730 (85%)	3913 (83%)
MD requested by EMT	823 (15%)	809 (17%)
Total	5553	4722

Table 4 6 Demographic Characteristics of Patients Receiving On-site Care by Physicians (Sample Ib', N = 4722)

Age (years)			
mean	37 3	median	31 0
s d	23 9	range	0-99

Gender	N*	(%)
male	3021	64
female	1651	36

Age category	N % of total	% male in age category
0-15	645 (14)	63
16-30	1699 (36)	69
31-45	992 (21)	67
46-60	565 (12)	65
> 60	820 (18)	51

* Gender data on 50 patients were missing.

Table 4 7 Location of Accident for Patients Receiving On-site Care by Physicians (Sample Data, N 4722)

Location	N	(%)
Motor vehicle accident (MVA)	2113	45
Domestic	1241	26
Workplace	255	5
Other	989	21

Data on location of accident for 124 patients were missing

Table 4 8 Mechanism of Injury for Patients Receiving On-site Care by Physicians (Sample Ia', N= 4722)

Mechanism of Injury	N*	(%)	
MVA	2113	45	
- Driver	565	12	[23]
- Passenger	273	6	[14]
- Motorcycle	190	4	[9]
- Bicycle	315	7	[16]
- Other means of transport	34	1	[2]
- Pedestrian	634	13	[32]
Firearms	117	2	
Stabbings	193	4	
Falls	1103	23	
Drownings	37	1	
Electrocution	35	1	
Fires	25	0 5	
Hanging	131	3	
Laceration	333	7	
Crushing	66	1	
Machinery	38	1	
Intoxication	8	0 2	
Overdose	2	0 04	
Fight	222	5	
Other	293	6	

* Data of mechanism of injury were missing for 226 patients.

[Percent of MVA]

Table 4.9 Body Regions Injured in Patients Receiving On-site Care by Physicians (Sample Ia', N = 4722).

Body Region	N (%)	% Penetrating for each region
Head/neck	2681 (57)	5
Chest	677 (18)	13
Abdomen	320 (7)	19
Spine	576 (15)	0
Extremities	2184 (46)	11

Number of Regions Injured	N*	%
1	3065	65
2	1079	23
3	271	6
4	63	1
5	30	0 5

* Data on body region injured was missing for 214 patients

Table 4 10 Pre-hospital Index (PHI) Scores of Patients Receiving On-site Care by Physicians (Sample Ia', N = 4722)

PHI

PHI Score	N*	%
0-3 (mild)	2225	79 5
4-8 (moderate)	175	6 2
9-24 (severe)	400	14 3

mean	3 7	median	0.0
s d	7 7	range	0-24

* Data required for calculation of PHI were available for only 2800 patients

N B 312 patients were dead upon arrival of the physician.

Table 4 11 Procedures Performed by Physicians Providing On-Site Care (Sample Ia', N = 4722).

Procedure	N	% of Total
Basic Life Support (BLS)		
Immobilization	1620	34 3
Wound Dressing	836	17 7
Oxygen Administration	643	13 6
Extrication	79	1 7
Advanced Life Support (ALS)		
Intubation	160	3 4
Intravenous Fluid Replacement	1218	25 8
Medication Administration	346	7 3
PASG Application	44	0 9
BLS only	3379	71 6
ALS & BLS	1343	28 4

Table 4 12 Pre-hospital Index (PHI) and Scene Time by On-site Care Provided by Physicians (Sample Ia', N = 4722)

	Pre-hospital Index (PHI)			Scene time (min)		
On-site Care	N*	Mean ± 1 s d	% severe (> 3)	N*	mean ± 1 s d	Range
No Procedures	832	0 6 ± 2 4	4	986	20 5 ± 11.6	0-130
BLS only	749	0 4 ± 1 3	3	956	19 7 ± 10 1	0-88
ALS	923	3 5 ± 6 6	24	977	24.3 ± 11 2	0-101
Number of ALS Procedures						
1	721	1.1 ± 2.1	16	771	23 4 ± 10 3	0-80
2	160	5 3 ± 6.3	49	170	26 7 ± 12 4	0-101
3	37	16 7 ± 5.9	98	36	31 0 ± 15.0	0-73
4	5	20 0 ± 0	100	7	29 3 ± 15 8	10-53
F**	--	427 3			22 1	
P**	--	≤ 0 0001			0 0001	

* Excluding 312 patients who were dead upon arrival of the physician

** Based on One-way Analysis of Variance

Table 4.13. Results of Multivariate Linear Regression for Predicting Scene Time

Variable	Parameter Estimate (b)	t for b = 0	P
Intercept	21 43	78 40	0 0
PHI	0 12	1.71	0 08
On-site care	2 05	7 33	0 001

Table 4 14 In-hospital Care for Patients Followed to the Hospital (Sample II, N = 928)

In-hospital Care	N	% of Total
Surgery	183	20
Intensive Care (ICU)	158	17
Surgery and ICU	81	8
None	506	55
ICU Duration (hrs)		
Mean	101 5	
S d	136.9	
Median	48	
Range	0 - 999	

4 15 Outcome of Patients Followed to Hospital (Sample II, N = 928)

Outcome	N	% of Total	
Discharged	788	85	
Transfer to long-term care facility	23	2	
Deceased	117	13	
Time to death (days)	N	% of Deaths	Cumulative %
0	64	55	55
1	22	19	74
2	8	7	81
3	2	2	83
4	1	1	84
5	3	3	87
6	2	2	89
> 6	15	11	100

Table 4 16 Demographic Characteristics and Comorbidity of Severely Injured Patients (Sample III, N= 360)

Variable				
Age		Gender :		
Mean	33 9	Male N (%)	255 (71)	
S d	19 4			
Median	29			
Range	0 - 84			
Age Categories		N	%	% Male
0 - 15		43	12	53
16 - 30		143	40	80
31 - 45		87	24	76
46 - 60		43	12	67
> 60		44	12	55
Comorbidity				
Pre-existing Condition (PEC)		N	%	
Cardiovascular		9	3	
Renal		3	1	
Pulmonary		19	5	
Diabetes		8	2	
Cirrhosis		2	0 6	
Cancer		3	0 8	
> 1		44	12	

Table 4.17 Observed and Expected Mortality (Sample III, N = 360)

Standard Population	Publication Year	Expected Deaths N (%)	Observed Deaths N (%)	Observed/ Expected (95% CI)	z^1	p^1
Bull	1974	41.85 (12)	72 (20)	1.72	7 09	< 0 0001
McLean	1988	19 51 (5)	72 (20)	3.69	23 77	< 0 0001
MTOS	1988	38 99 (11)	72 (20)	1 85	6 77	< 0 0001
TRISS*	1987	24 14 (23)	42 (40)	1 74	4 14	< 0 0001

Abbreviations - MTOS: Major Trauma Outcome Study
TRISS Trauma Injury Severity Score

1 Based on method developed by Flora (Flora,1987)

* Data required were available for only 103 patients

Table 4 18 Expected and Observed Mortality by On-site Care (Sample III, N = 360)

On-site Care	N	Expected Deaths N (%)	Observed Deaths N (%)	Observed/ Expected (95% CI)	Z^1	P
EMT only	47	1 6 (3)	2 (4)	1 25 (0 15-4 51)	0 34	0 734
MD						
- no procedures	37	1 6 (4)	2 (5)	1.25 (0 15-4 51)	0 40	0 689
- BLS only	37	1 4 (4)	4 (11)	2.86 (0 78-7 32)	2 52*	0 012
- BLS & ALS	239	34 5 (4)	64 (27)	1 86 (1 43-2 34)	6 54	<< 0 0001
Test for Heterogeneity X_3^2 = 1 86, p = 0 60						
Test for Trend X_1^2 = 0 14, p = 0 71						
BLS	121	4 6 (4)	8 (7)	1 74 (0 75-3 43)	1 83	0 087
ALS	239	37 2 (16)	64 (27)	1 72 (1 43-2 34)	6 54	<< 0 0001

X_1^2 = 0 05, p = 0 82

1 Based on methods developed by Flora (Flora,1978).

* Modified Z statistic using square root transformation for this group was 1 88, p - 0 060.

N B Chi-Square analysis based on method for comparing standardized mortality rates between groups developed by Breslow and Day (Breslow and Day, 1987.82-100).

Table 4 19. Expected and Observed Mortality by ACS-Compatibility of Receiving Hospital (Sample III, N = 360)

ACS Compatibility	N	Expected Deaths N (%)	Observed Deaths N (%)	Observed/ Expected (95% CI)	Z[1]	P
I	158	18 9 (12)	31 (20)	1 64	3 60	0 0003
II	109	13 9 (13)	27 (25)	1 94	3 52	< 0 0004
III	93	6 2 (7)	14 (5)	2 26	3 84	< 0 0001

Test for Heterogeneity X_2^2 = 1 93, p = 0 38

Test for Trend X_1^2 = 4 33' p = 0.037

1 Based on methods developed by Flora (Flora,1978)

N B Chi-Square analysis based on method for comparing standardized mortality rates between groups developed by Breslow and Day (Breslow and Day, 1987 82-100).

Table 4 20 Expected and Observed Mortality by Time to Arrival at the Hospital. (Sample III, N** = 272)

Time to Hospital (min)	N	Expected Deaths N (%)	Observed Deaths N (%)	Observed/ Expected (95% CI)	Z[1]	P
0 - 15	22	2 6 (12)	4 (18)	1.54	1.03	0 300
16 - 30	69	5 0 (7)	10 (14)	2 00	2 66	0 008
31 - 45	124	17 1 (14)	26 (21)	1 52	2 83	0 005
46 - 60	44	4 8 (11)	6 (14)	1 25	0 77	0 430
> 60	13	0 5 (4)	4 (31)	8 00	5.10***	<< 0 0001

Test for Heterogeneity X_4^2 = 13 11, p = 0 01

Test for Trend X_1^2 = 0 31, p = 0 58

X_1^2 = 2 37, p = 0 12

≤ 60	259	29 5 (11)	46 (17)	1 56 (1 05-2.27)	3 43	< 0.0001
> 60	13	0 5 (4)	4 (31)	8.00 (2 18-20.48)	5.10	<< 0 0001

X_1^2 = 61 6, p < 0 0001

1 Based on methods developed by Flora (Flora, 1978)

** Data on Time to Arrival at Hospital was missing for 88 patients

*** Modified Z statistic using square root transformation for this group was 2 60, p = 0 008

N B Chi-Square analysis based on method for comparing standardized mortality rates developed between groups by Breslow and Day (Breslow and Day, 1987 82-100)

Table 4 21 Unconditional Logistic Regression Incorporating Expected Mortality by MTOS Standardization *

Full Multivariate Model

Variable	Estimate	S E	Estimate/S E	Odds Ratio (95% CI)
ALS (vs BLS)	0 3245	0 5727	0 57	1 4 (0 4 - 4 2)
ACS Comparability (I,II,vs III)	-0 3352	0 2684	-1 25	0 7 (0 4 - 1 21)
Time to hospital (vs time ≤ 60 min)	3 394	1 2328	2 76	29 9 (2 7 - 33 3)
ISS (vs ISS < 15)	1.390	1 039	1 34	4 0 (0 5 - 30 8)

MODEL SCALED DEVIANCE = 16.62

DF = 14

* Using Log Odds (expected probability of death/expected probability of survival) as OFFSET in GLIM statistical software as suggested by Breslow and Day for multivariate modelling incorporating external standard rates

Table 4 22 Demographic Characteristics of Cases and Referents (Sample III, N = 360).

Variable	Total	Cases	Referents	
N	360	72	288	
Age (yrs)				
mean	33 9	35 6	33 5	t= 0 74
s d	19 5	22 6	18.6	
median	29	29 5	29 0	p= 0 46
range	0 - 84	1 - 84	0 - 83	
Age Category (yrs)	N (%) Male (%)	N(%) Male (%)	N (%) Male (%)	
0 - 15	46 (13) 50	34 (12) 62	12 (17) 33	
16 - 30	142 (40) 80	117 (40) 79	25 (35) 88	
31 - 45	85 (24) 75	72 (25) 78	13 (18) 62	
46 - 60	43 (12) 67	36 (13) 69	7 (10) 57	
> 60	44 (12) 55	29 (10) 52	15 (21) 60	

Age $X^2_4 = 9\ 13$, $p = 0\ 06$, Test for trend $X^2_1 = 0\ 84$, $p = 0\ 344$

Gender $X^2_1 = 1\ 35$, $p = 0\ 25$

Table 4 2: Comorbidity in Cases and Referents Odds Ratios for Presence of Pre-existing Comorbid Conditions. (Sample III, N = 360).

Co-morbid Condition (PEC)	N (%) Total	Cases	Referents	Odds Ratio* (95% CI)
N	360	72	288	---
Cardiovascular	9 (3)	4 (5)	5 (2)	3 3 (0 93 - 11 8)
Renal	3 (1)	0 (0)	3 (1)	0 7 (0 03 - 13 9)
Pulmonary	19 (5)	7 (10)	12 (4)	2 5 (1 0 - 6 4)
Diabetes	8 (2)	3 (14)	5 (2)	2 5 (0 6 - 10 0)
Cirrhosis	2 (0 6)	1 (1)	1 (0 3)	4 0 (0 3 - 53 0)
Cancer	3 (0 8)	1 (1)	2 (0 7)	2 0 (0 2 - 21 5)
≥ 1 PEC	44 (12)	16 (22)	28 (10)	2 6 (1 4 - 5 1)

* Crude unadjusted odds ratio for presence of the condition compared to absence of condition

Table 4 24 Injury Characteristics of Cases and Referents. Odds Ratios for location of Accident (Sample III, N = 360)

Location of Accident	N (%) Total	Cases	Referents	Odds Ratio* (95% CI)
N	360	72	288	---
Home	93 (26)	8 (11)	85 (30)	0 3 (0.14 - 0.63)
Workplace	13 (4)	0 (0)	13 (5)	0.15 (0 01 - 1 73)
Circulation (MVA)	131 (37)	44 (61)	87 (30)	3 6 (2 1 - 6 1)

$X^2_4 = 31\ 7,\ p < 0\ 001$

Data on location of accident were missing for 54 subjects, and 69 accidents occurred in locations other than those specified

Abbreviations, MVA Motor Vehicle Accident

* Crude unadjusted odds ratio compared to accident not occurring in the location

Table 4 25 Injury Characteristics of Cases and Referents Odds Ratios for Mechanism of Injury (Sample III, N = 360)

Mechanism	Total N (%)	Cases N (%)	Referents N (%)	Odds Ratio* (95% CI)
N	360	72	288	---
Firearm	19 (5)	8 (11)	11 (4)	3 1 (1 3 - 7 8)
Stabbing	61 (17)	4 (6)	57 (20)	0 2 (0 1 - 0 6)
Falls	53 (15)	10 (14)	43 (15)	0 9 (0 4 - 1 9)
Electrocution	3 (0 8)	0 (0)	3 (1)	0 7 (0 03 - 13 2)
Hanging	7 (2)	3 (4)	4 (1)	3 0 (0 7 -13 1)
Lacerations	25 (7)	1 (1)	24 (8)	0 1 (0 03 - 0 9)
Crushing	5 (1)	0 (0)	5 (2)	0 4 (0 02 - 6 7)
Fight	5 (1)	0 (0)	5 (2)	0 4 (0 02 - 6 7)
MVA				
Driver	25 (7)	7 (10)	18 (6)	1 6 (0 6 - 4 0)
Passenger	12 (3)	4 (6)	8 (3)	2 1 (0 6 - 6 9)
Motorcycle	14 (4)	7 (10)	7 (2)	4 3 (1 6 - 11 8)
Bicycle	12 (3)	3 (4)	9 (3)	1 3 (0 4 - 5 1)
Pedestrian	62 (17)	22 (30)	40 (14)	2 7 (1 5 - 4 9)

X^2 = 36 8, DF = 12, p = 0 002

Abbreviations - MVA Motor Vehicle Accident

* Crude unadjusted odds ratio for mechanism causing the injury compared to specific mechanism not being associated with the injury

Table 4 26 Injury Characteristics of Cases and Referents Odds Ratios for Body Regions Involved (Sample III, N = 360)

	N (%)			
Body Region	Total	Cases	Referents	Odds Ratio* (95% CI)
N	360	72	288	---
Isolated Head	23 (6)	9 (13)	14 (5)	2 8 (1 2 - 6 7)
Head	135 (37)	56 (78)	79 (27)	9 3 (5 0 - 17 1)
Chest	105 (29)	39 (55)	66 (23)	3 9 (2 3 - 6 8)
Abdomen	88 (25)	25 (55)	63 (22)	1 9 (1 1 - 3 3)
Extremities	151 (42)	27 (38)	124 (43)	0 8 (0 5 - 1 4)
Face	30 (8)	8 (11)	22 (8)	1 5 (0 6 - 3 6)
External	208 (58)	47 (65)	161 (56)	1 5 (0 8 - 2 5)
Number of Regions				
1	162 (45)	14 (20)	148 (51)	
2	114 (32)	23 (32)	91 (32)	X^2 = 51 6
3	54 (15)	16 (22)	38 (13)	DF = 4
4	15 (4)	9 (12)	6 (2)	p < 0 0001
5	15 (4)	10 (14)	5 (2)	
> 1 Regions	198 (55)	58 (81)	140 (49)	4 4 (2 4 - 8 2)**
Penetrating Trauma	78 (22)	6 (8)	72 (25)	0 3 (0 1 - 0 7)***

* Crude unadjusted odds ratio for specific body region being injured compared to body region not being injured

** Crude unadjusted odds ratio for multiple regions being injured compared to single body region injury

*** Crude unadjusted odds ratio for penetrating trauma compared to blunt trauma

Table 4 27 Injury Characteristics Injury Severity (Sample III, N = 360)

ISS	Total	Cases	Referents	
N	360	72	288	
Mean	13 7	29.0	9 9	t = 13 4
S d	12 2	11 3	9 0	
Median	10	27 0	9 0	p = 0 0001
Range	1 - 59	5 - 59	1 - 43	
TS				
N	103	38	65	
Mean	11 4	9 3	12 7	t = 4 6
S d.	3 7	3 9	3 0	
Median	12 0	10.5	13 0	p = 0 0001
Range	1 - 16	1 - 16	4 - 16	

N (%)

ISS Categories	Total	Cases	Referents
N	360	72	288
0 - 14	230 (64)	5 (7)	225 (78)
15 - 24	45 (12)	13 (29)	32 (11)
25 - 59	85 (24)	54 (64)	31 (11)
≥ 15	130 (36)	67 (93)	63 (22)

X^2_2 = 148 6, p < 0 0001 [ISS 3 categories], Test for trend X^2_1 = 147 8, p = < 0 0001

X21 = 126 5, p < 0 0001 [ISS 2 categories]

Abbreviations, ISS Injury Severity Score
TS Trauma Score

Table 4 28 System Times for Cases and Referents (Sample III, N = 360)

Time Interval (min)	Total	Cases	Referents	t	p
Response					
N	307	60	247		
Mean	7 6	7 5	7 7	0 26	0 79
S d	4 9	4 2	5 0		
Median	7 0	7 0	7 0		
Range	0 - 33	0 - 23	0 - 33		
Scene					
N	315	60	255		
Mean	20 0	21 2	19 8	0.98	0 33
S d	10 4	10.3	10.4		
Median	20 0	20 0	19 0		
Range	0 - 57	0 - 46	0 - 57		
Transport					
N	315	60	255		
Mean	7 7	7.8	7 6	0 16	0 87
S d	7 1	10.4	6 1		
Median	6 0	5 5	6 0		
Range	0 - 57	0 - 57	0- 39		
Total					
N	272	50	222		
Mean	35 6	37 1	35 2	0.73	0 47
S d	15 3	17 1	14 9		
Median	35 0	34 5	35.0		
Range	0 - 84	0 - 84	0 - 80		

Data on Response Time were missing for 53 patients

Data on Scene and Transport Time were missing for 45 patients

Data on Total Time were missing for 88 patients

Response Time = Call to arrival of ambulance at scene

Scene Time = From arrival of ambulance at scene to departure

Travel Time = From departure from scene to arrival at hospital

Total Time = From call to arrival at hospital

Table 4 29 Time from Call to Arrival at Hospital for Cases and Referents (Sample III, N = 360) and Associated Odds Ratios

Time Interval (min)	N (%) Total	Cases	Referents	
N	272	50	222	
0 - 15	22 (8)	4 (8)	18 (8)	X^2_4 = 3 3
16 - 30	69 (25)	10 (20)	59 (27)	
31 - 45	124 (46)	26 (52)	98 (44)	p = 0 52
46 - 60	44 (16)	6 (12)	38 (17)	
0 - 60	259 (95)	46 (92)	213 (46)	OR = 1 0
> 60	13 (5)	4 (8)	9 (4)	OR* = 2 0 95% C I = 0 7 - 6 8
0 - 30	91 (33)	14 (28)	77 (35)	OR = 1 00
> 30	181 (67)	36 (72)	145 (65)	OR** = 1 4 95% C I = 0 7 - 2 7

* Crude unadjusted odds ratio of being a case for total time > 60 minutes compared to total time < 60 minutes

** Crude unadjusted odds ratio of being a case for total time > 30 minutes compared to total time < 30 minutes

Table 4 30 On-site Care for Cases and Referents (Sample III, N = 360) and Associated Odds Ratios

	N (%)			
On-site Care	Total	Cases	Referents	Odds Ratio* (95% CI)
N	360	72	288	---
EMT - only	47 (13)	2 (3)	45 (16)	1 00
MD				
- no procedures	37 (10)	2 (3)	35 (12)	1 3 (0 2 - 9 5)
- BLS only	37 (10)	4 (5)	33 (11)	2 7 (0.5 - 14 9)
- ALS	239 (66)	64 (89)	175 (61)	8 2 (2 4 - 28 2)

X^2 = 21 02, DF = 3, p < 0 0001

* Crude estimates of odds ratio of being a case associated with specific on-site care compared to EMT-only

Table 4 31 ACS-Classification Compatibility of Receiving Hospitals for Cases and Referents (Sample III, N = 360)

ACS Compatibility of Receiving Hospital	N (%) Total	Cases	Referents
I	158 (44)	31 (43)	127 (44)
II	109 (30)	27 (38)	82 (29)
III	93 (26)	14 (19)	79 (27)

$X^2_2 = 2\ 9$, $p = 0\ 225$, Test for trend. $X^2_1 = 0\ 42$, $p = 0\ 519$

Table 4 32 Crude Unadjusted Odds Ratio for Being a Case Associated with ALS (Sample III, N = 360)

	N		
	Cases	Referents	Total
ALS	64	175	239
BLS	8	113	121
Total	72	288	360

OR = 5 17, 95% CI = 2 39 = 11 8

Table 4 33. Summary of Stratified Analysis Adjusted Odds of Dying Associated with Treatment by ALS (Sample III, N = 360)

Stratification/ Adjusting Variable	Adjusted Mantel-Haenzel Odds Ratio	95% CI
Age	5 1	2 5 - 10 6
Comorbidity (PEC)	5 1	2 5 - 10 5
Location of Accident	5 5	1 5 - 23 7
Body Region Injured*		
- Isolated Head	4 9	2 4 - 10 1
- Head	2 8	1 1 - 6 7
- Chest	4 3	2 0 - 9 0
- Abdomen	4 9	2 4 - 10 4
- Extremities	5 1	2 5 - 10 4
Multiple Body Region	4 7	2 2 - 9 8
Injury Type	5 5	2 7 - 11 2
ISS	1 6	0 6 - 4 3
Time to Hospital	5 9	2 5 - 14 3
ACS - Hospital Compatibility	5.1	2 5 - 10 7
In-hospital Care	4 7	2 2 - 9 9
Unadjusted Odds Ratio	5 2	2 4 - 11 2

PEC Pre-existing condition in any of the following categories Cardiovascular, Renal, Pulmonary, Diabetes, Cirrhosis, Cancer

* Stratification by AIS categories (1-3, 4-5) with exception for Isolated Head (YES/NO)

Age (years) 0-15/ 16-30/ 31-45/ 56-60/ > 60

Location of Accident Home & Work/ Motor Vehicle Accident

Injury Type Penetrating/Blunt

ISS 1 14/ 15-24/ 25-59

Time to Hospital 0-30/ 31-60/ >60

ACS - Hospital Compatibility I/ II/ III Compatibility

In-Hospital Care None/ Surgery/ ICU/ Surgery & ICU

Table 4 34 Stepwise Logistic Regression (Sample III, N = 272)

Final Model

Variable	Estimate	S E	Estimate/S E	Odds Ratio (95% CI)
Age[1]	0 014	0 009	1 556	1 01 (0 99 - 1 03)
ISS[2]	2 09[illegible]	0 246	8 540	8 16 (5 04 - 13 21)
MVA[3]	0 491	0 194	2 531	1 63 (0 17 - 23 9)
Time to hospital[4] (≤ 60 min)	1 100	0 445	2 497	3 00 (1 23 - 7 33)
Gunshot Injuries[5]	0 884	0 348	2 54	2 42 (1 22 - 4 79)
ACS compatibility[6]				
I vs II	0 062	0 268	0 231	1 06 (0 63 - 1 80)
I vs III	-0 359	0 254	-1 411	0 69 (0 43 - 1 15)

Outcome Case = 1, Referent = 0

Variables entered in model but not fulfilled entry/exit criteria
- Gender (M/F 1/0)
- PEC (Any condition in Cardiovascular, Pulmonary, Renal, Diabetes, Cirrhosis, Cancer)
- Headneck injury (YES/NO 1/0)
- Chest injury (YES/NO 1/0)
- Abdominal injury (YES/NO 1/0)
- Advanced Life Support ALS (YES/NO 1/0)

1 Age continuous

2 ISS coded as 1 = 1-15, 2 = 16-24, 3 = > 25

3 MVA = 1 = YES, 0 = NO

4 Time to hospital coded as 0 = 0-60 min , 1 = > 60 min

5 Gunshot injuries 1 = YES, 2 = NO

6 ACS compatibility I/II/III 3/2/1

Table 4 35 Logistic Regression Final Model (Sample III, N = 272)

Variable	Estimate	S E	Estimate/S E	Odds Ratio (95% CI)
Age[1]	0 013	0 009	1 446	1 01 (0 99 - 1 03)
ISS[2]	2 120	0 259	8 186	8 33 (5 01 - 13 84)
MVA[3]	0 490	0 199	2 453	1 63 (1 10 - 2 41)
Time to hospital[4] (≤ 60 min)	1 103	0 439	2 508	3 01 (1 27 - 5 06)
Gunshot Injuries[5]	0 915	0 359	2 545	2 50 (1 23 - 1 83)
ALS[6]	0 081	0 268	0.303	1 08 (0 64 - 1 83)
ACS-Classification Compatibility of Receiving Hospital[7]				
I vs II	0 028	0 331	0 084	1 03 (0 54 - 1 97)
I vs III	-0 480	0 3007	-1 597	0 62 (0 34 - 1 12)

1 Age continuous

2 ISS coded as 1 = 1-15, 2 = 16-24, 3 = > 25

3 MVA = 1 = YES, 0 = NO

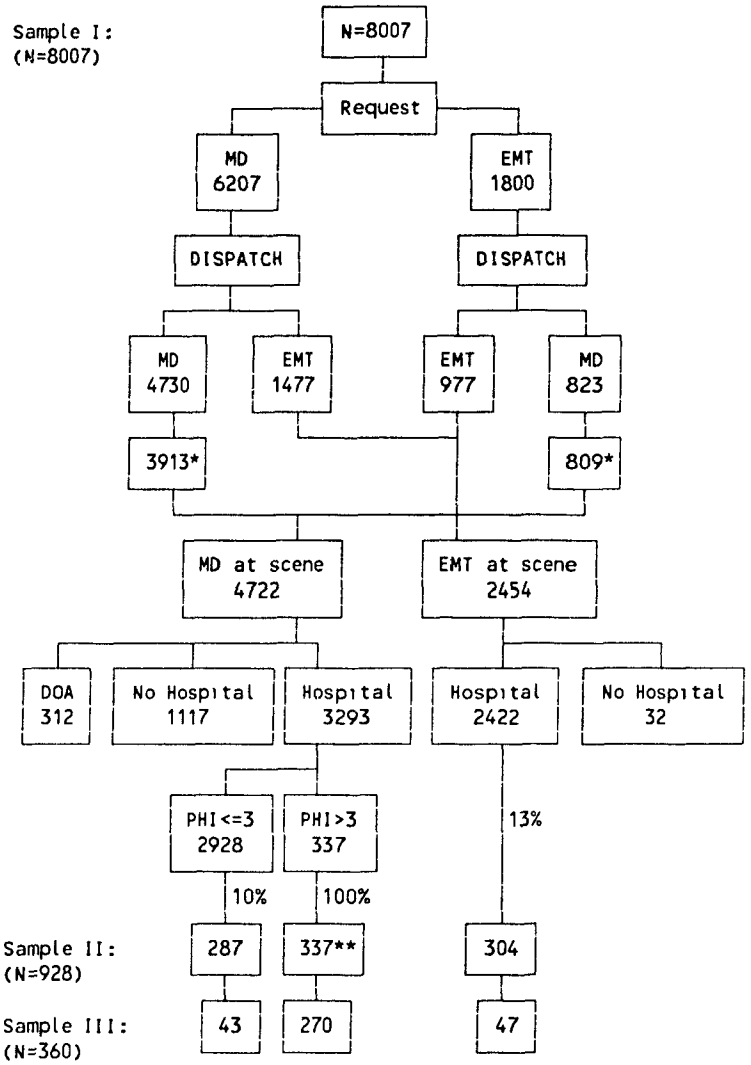
4 Time to hospital coded as 0 = 0-60 min , 1 = > 60 min

5 Gunshot injuries 1 = YES, 2 = NO

6 ALS codes as 1 = MD + ALS, 0 = BLS (EMT only, MD & no procedures, MD & BLS only)

7 ACS-classification compatibility of receiving hospital codes as I/II/III 3/2/1

Figure 4.1 - Sampling Procedures and Assembly of Final Sample



* = MD records retrieved.
** = 33 deaths were excluded (30=immediate, 3=fatal injuries).
DOA = dead on arrival of ambulance and physician

CHAPTER 5. DISCUSSION

5.1. Introduction

This was an observational study describing and evaluating emergency trauma services in Montreal. Pre-hospital emergency services in Montreal are provided by Urgences-Santé a non-profit organization employing nurses, emergency medical technicians (EMT), and physicians (MD). The Urgences-Sante system is unique in North America in that physicians may be dispatched to the field to provide emergency care to critically ill or severely injured individuals. Advanced life support is provided only by physicians as EMTs provide only basic life support.

Hospital-based trauma care in Montreal is not regionalized. Although hospitals affiliated with medical schools may provide high level trauma care, these hospitals are not organized as formally recognized trauma centres. Patient triage protocols are not implemented. Patients are transferred to the nearest hospital with an emergency room.

The impact of the Urgences-Sante system as a whole, and of the pre-hospital and in-hospital level of trauma care were evaluated using indirect standardization to the Major Trauma Outcome Study population. The association on-site ALS provided by MDs with the odds of dying in severely injured patients was estimated using a non-matched case-referent design.

5.2. Study Findings

5.2.1. Description of Trauma-related Emergency Medical Services in Montreal

Over 20,000 calls for trauma emergencies were received at Urgences-Santé between April 1st, 1987 and March 31st, 1988. The nurse requested an MD for approximately one-third of these calls. There were 1477 calls for which the nurse's request for an MD did not result in an MD attending the trauma site. This represents 24% of the total calls for which an MD was requested. Of the 13,392 calls for which a nurse did not request an MD, an MD was eventually dispatched to the site following a request by the EMT in 6%. This figure represents a minimum estimate because the number of requests by an EMT for an MD that were not met was unavailable.

The response, scene, transport, and total times for Urgences-Santé are similar to those reported in the literature (Table 5.1). The data show that the response of Urgences-Santé is comparable to that of systems in other major North American cities. This was observed in spite of the presence of labour unrest during the time of the study between Urgences-Santé management and ambulance EMTs. The impact of these conditions on the results cannot be assessed. In the present study, the mean total time from call to hospitalization was longer by five minutes when an MD was originally dispatched to the scene, as compared to

when only an EMT was dispatched. This time interval was 10 minutes longer when the EMT subsequently requested an MD (Chapter 4, Table 4.4).

The level of on-site care provided by a physician was also significantly associated with increased mean scene and total pre-hospital times. As the level of on-site care increased from no on-site procedures to ALS in general, the mean total time increased by four minutes. The mean scene time increased by nine minutes when four different ALS procedures were performed. Finally, in the sample of severely injured patients (Sample III), the use of ALS was significantly associated with increased odds of delays to hospitalization exceeding 30 minutes (Table A.8). Thus the use of ALS at the scene delayed transfer to a hospital. Although the clinical importance of a mean five-minute delay may be contested, delays of 10 minutes may have clinically significant consequences for patients with major hemorrhage (Trunkey,1983; Smith et al.,1985).

In addition, the use of ALS significantly increased scene time after controlling for injury severity. Thus, as the injury severity increased and the requirement for immediate definitive in-hospital care became more necessary, the use of ALS continued to significantly increase the delay to hospitalization. On-site ALS may be less appropriate for severely injured patients who require hospital care (Tables 4.12, 4.13) particularly when hospitals are a short distance from the scene of the accident.

5.2.2. Impact of Emergency Medical Services on Trauma Mortality

The methods available to evaluate the impact of emergency medical services on trauma mortality are limited. As was discussed in the first chapter, one of the methods often used utilizes the preventable death rate as an outcome measure. This method has been criticized for lack of standardization in defining preventable deaths, thus limiting comparisons across studies. Furthermore, referral patterns may result in biased estimates of preventable death rates for specialized centres receiving with particularly severe injuries.

An alternative method involves the indirect standardization of the study sample with an external standard population. Expected mortality rates are computed on the basis of injury severity and other parameters including type of injury, and age. Observed to expected ratios of deaths or differences between observed and expected deaths are used as the outcome measure in such studies. This technique was used in the present study.

The standard population used to calculate the expected deaths was the Major Trauma Outcome Study (Copes et al.,1988). Probabilities of death for each patient were determined on the basis of the ISS score, age and type of injury as penetrating or blunt. This sample was selected because of the large sample size (14,786) from over 100 hospitals in North America, and because the range of the

patient age was comparable to that in our sample. There were 72 observed deaths in the sample of 360 severely injured patients. Applying the MTOS probabilities to our patients resulted in 38.99 expected deaths. There were 33 more deaths than might have been expected.

The bivariate analyses evaluating the impact of various components of the emergency medical services on the observed to expected mortality ratios showed that the standardized mortality ratio was similar for the patients receiving on-site ALS and for those receiving on-site BLS. However, these data showed that the number of observed deaths in the ALS group was significantly higher than the number expected ($z = 6.54$; $p << 0.0001$). For the patients receiving only BLS, the observed and expected number of deaths were not significantly different ($z = 1.83$; $p = 0.087$).

The analysis comparing standardized mortality ratios by receiving hospital show that these ratios decrease as the level of in hospital care improves from ACS-level III to level I compatible ($X^2_1 = 4.33$, $p = 0.037$). Delays to hospitalization exceeding 60 minutes resulted in a significant standardized mortality ratio of 8.00 ($X = 5.10$, $p << 0.0001$). This was significantly higher than the ratios obtained for shorter delays to hospitalization.

Using multivariate logistic regression, delays to hospitalization exceeding 60 minutes were significantly associated with a 30-fold increase in the standardized mortality ratio. Treatment at an ACS-level I or II

compatible hospital was associated with a 30% reduction in the standardized mortality rate. The use of on-site ALS by the physicians was not found to be associated with a reduction in the standardized mortality ratio.

5.2.3. Impact of Emergency Medical Services on Odds of Dying

The most appropriate method for evaluating therapeutic interventions is the randomized controlled trial. However, such a design is generally not feasible for the evaluation of pre-hospital services. The alternative methodology is that of an observational study. The main problem with observational studies is that because treatment allocation is not random, the treatment groups may vary significantly with respect to important prognostic variables. These differences may result in bias and consequently confounding of the results. Design features such as proper sampling or matching may be used to prevent such bias; however implementation of these precautionary measures is not always possible. Analysis of observational evaluative studies should carefully evaluate the presence of potential bias and the degree of confounding. Statistical techniques such as stratified analysis producing adjusted estimates of risk ratios or multivariate methods must be used to control for the effect of the confounding.

The primary determinant or independent variable in the present study was the use of on-site ALS by the physicians. Confounding was assessed by univariate comparisons between

outcome and treatment groups. Stratified analysis by single stratification variables was used to evaluate the extent of confounding and to obtain adjusted estimates of the association between ALS and the odds of dying. Multivariate logistic regression was used to estimate the adjusted independent association of the use of ALS and the odds of dying while simultaneously controlling for other covariates.

The crude odds ratio of dying showed a statistically significantly increase in the odds of dying associated with the use of ALS (OR = 5.17; 95% CI = 2.39 - 11.8). Comparison of the two outcome (cases, referents) and the two treatment groups (ALS, BLS) suggested that confounding was present, especially with respect to the ISS and the presence of head injuries. Stratified analysis controlling for the ISS confirmed this observation. The adjusted odds ratio was 1.6 (95% CI = 0.6 - 4.3) which indicated a non-significant association between ALS and odds of dying. The OR adjusted for the presence of head injury was 2.8 (95% CI = 1.1 - 6.7).

The results of multiple logistic regression showed that the use of on-site ALS was not associated with survival to seven days (case). The variable representing the use of ALS did not meet the stepwise selection criteria. When ALS was forced into the model, ALS was not associated with a decrease in the odds of dying, as the estimate of the odds ratio was only 1.08 (95% CI = 0.64 - 1.83). However, the variable representing the level of trauma care in the

receiving hospital was selected in the stepwise model. The results showed that treatment in an ACS-level I compatible hospital was associated with a decreased odds of dying (OR = 0.62; 95% CI = 0.34 - 1.12). The coefficient for this variable approached statistical significance.

The most significant determinant of an increased odds of dying, with the exception of ISS, was total pre-hospital time exceeding 60 minutes (OR = 3.00; 95% CI = 1.23 - 7.33). Injury from a gunshot wound was also associated with an increased odds of dying (OR = 2.42; 95% CI = 1.22 - 4.79) as was being involved in motor vehicle accident (OR = 1.63; 95% CI = 1.17 - 2.39). Age as a continuous variable was associated with an increased odds of dying (OR = 1.01; 95% CI = 0.99 - 1.03), although the coefficient only approached statistical significance.

5.3. Limitations of the Study

5.3.1. Limitations of Observational Studies in General

The use of the experiment is the best method available for evaluating medical interventions. The randomized controlled trial (RCT) provides the strengths of the true experiment, specifically definition and control of treatment allocation, and the means to minimize bias. In a randomized trial, the investigator randomly assigns each patient to the study groups while minimizing bias through design features such as stratification. Therefore, the probability of confounding seriously affecting the results is minimized.

Another benefit of an RCT is that the method of treatment administration is explicitly defined. Overlap between treatments and within group variation with respect to the treatment received is theoretically eliminated. Therefore, the results of properly designed and executed RCTs are considered as highly reliable and powerful evidence for the evaluation of medical interventions.

The use of an RCT however, is not always possible. As is the case for evaluation of emergency medical care, ethical and political barriers inhibit the implementation of an RCT. The alternative method of evaluating emergency cares is what Feinstein defines as survey-type impact research (Feinstein, 1985). In this type of research the prescription of the different treatments to the patients is not part of the study. The investigators collect data on the outcome in groups of patients receiving the different treatments of interest. Comparisons between such groups are used to evaluate the relative effectiveness of the two treatments.

The survey impact research design is associated with potential problems that are primarily caused by the lack of randomization of patients into treatment group, and by the fact that the treatment regimens are not precisely defined. One of the tasks of the investigator is to compensate for these flaws either in the design or the analysis phase of such research.

The lack of randomization may result in non-comparable study groups due to biased treatment allocation or selection of patients to be included in the study. Such bias may result in confounding which has to be recognized and controlled for in the analysis of the data.

The definition of the treatment or intervention under evaluation or comparison should be clearly specified before initiation of the study. However, it is often difficult to determine whether and how the study intervention was used and to separate its effect from that of other concurrent treatments. Furthermore, it is often more difficult to determine what the control treatment is and whether a patient was subjected to this mode of treatment. Feinstein points out that one of the most difficult aspects in such studies is to define the principal maneuver and to determine whether it was used or not (Feinstein,1985:230-231).

Although the survey-type design is associated with these potential inherent problems, it is a widely used alternative when RCTs are not possible. The onus is on the investigator to recognize the potential problems of the study and either control for them or objectively acknowledge their impact on the results. By using careful designs which minimize bias and by adequately controlling for potential confounders, such studies may provide valid data. The results then could provide valuable information regarding the effectiveness of interventions, or refine a research hypothesis so that it may be addressed in a clinical trial.

5.3.2. Limitations of the Injury Severity Score (ISS)

The Injury Severity Score (ISS) is an anatomical index of injury severity which was developed in the early 1970's by Baker. The development of the ISS was prompted by the need to provide a standard measure of injury severity with had a strong association with trauma-related mortality. The Abbreviated Injury Scale (AIS) and its derivative, the maximum AIS, which were used prior to the development of the ISS, were poorly correlated with mortality because they did not account for injuries to more than one body region. As is described in Chapter 1, Baker solved this problem by introducing the ISS. The ISS is the sum of the squared AIS scores for the three most severely injured body regions. The ISS was shown to be strongly correlated with mortality and disability (Baker et al.,1973; Bull,1974).

Since its development, the ISS has been widely used as an anatomical index of injury severity. It has been applied as a standardized method for describing and controlling for injury severity in evaluative or descriptive studies. However, recently the ISS has been criticized for its inaccuracy in predicting mortality and for short-comings related to the validity of the ISS itself.

The reasons for these criticisms are based on the fact that a high ISS score (ISS $\geq$ 25) may be achieved by a single major injury (1 AIS of 5, => ISS = 25) or three lesser injuries (3 AIS of 3, => ISS = 27). However, the risk to the patient's life by the three separate injuries in

the latter case may not be necessarily additive. As a resu t, the patient with an ISS of 27 may have a higher survival probability when compared to the patient with an ISS of 25 who had a single major or nearly fatal injury.

As Copes points out, because a specific ISS value may arise from various combinations of three AIS scores, comparing patients with similar ISS, without considering the specific AIS combinations resulting in the ISS, may be misleading (Copes et al.,1988).

Another short-coming of the ISS is that it focuses only on the most severe injuries per body region while ignoring all other injuries in the same region. A patient with a major injury in one body region, for example the chest, will have an ISS of 25. Another patient with a similar injury and two other major injuries to the chest, (for example from multiple gunshot wounds, a victim may have damage to a heart muscle, a lung and a major artery), will also have an ISS of 25. The probability of survival for these two patients and their clinical presentation is considerably different regardless of the same ISS.

Another related issue is that the ISS is derived from an assessment of only three body regions. Thus in the case of severe injuries to more than three regions, the ISS will be underestimating the extent of true anatomical damage.

In spite of these shortcomings the ISS is the best available and most widely used anatomical measure of injury severity. It has been used extensively in both a descriptive

fashion and as a covariate to control for injury severity in evaluative studies. The ISS has provided a standardized measure of comparing injuries from different studies and settings, and has introduced a common language of communication for researchers in the area of trauma care.

5.3.3. Specific Limitations of the Current Study

The sampling that was applied in this study was aimed at selecting a subset of patients that would provide the appropriate sample for the evaluation of pre-hospital trauma care. As was discussed earlier, such a sample would consist of patients with severe but survivable injuries. We therefore decided to implement the sampling that was described in chapters 1 and 3. The purpose of this sampling was to include patients with injuries in the mid range of severity, thus excluding all cases of minor trauma and all unsurvivable injuries.

However, by introducing these sampling procedures, although any potential bias associated with including cases of minor trauma was avoided, the possibility of other biases related to the over representation of patients who were treated by a physician was introduced. These biases and their potential effect on the results will be discussed in the next sections.

5.3.3.1. Susceptibility Bias

Susceptibility bias in evaluative studies arises when the compared treatments are given to groups of patients who have significant baseline differences with respect of important prognostic variables (Schlesselman,1982:141-142; Feinstein,1985;44-45). According to Feinstein, the most common cause of susceptibility bias is allocation bias. This occurs when the treatments are either self-selected or clinically assigned for patients with significant differences in variables strongly associated with the outcome (Feinstein,1985;461). Randomization in controlled trials is intended to reduce or eliminate susceptibility bias although this method may not always be successful.

Allocation bias operated in our study because the determination of whether ALS was used or not was predominantly depended upon the clinical judgement of the nurse, the EMT or the physician. The decision to provide ALS was dependent on the injury severity as perceived by the nurse during the telephone conversation, or the EMT or MD on the scene. Because injury severity is associated with the outcome (death) and it was a determining factor in providing ALS treatment, the two treatment groups were different with respect to this parameter. This was confirmed by the significantly higher mean ISS of the ALS group compared to the BLS group [mean ($\pm$ 1 s.d.) ISS: ALS: 16.7 $\pm$ 13.0, BLS: 7.9 $\pm$ 7.7, $t = 6.8$, $p = 0.0001$]. In addition, the two treatment groups were significantly different with respect

to other significant predictors of mortality, specifically: involvement in a motor vehicle accident, proportion with firearm injury, being a pedestrian stuck by an automobile, having isolated head injuries, chest injuries, abdominal injuries, or having multiple system injuries (Appendix C).

The effect of confounding due to susceptibility bias was most noticeable with respect to the ISS and presence of head injuries, as indicated by the difference between the OR adjusted for these variables and the crude OR.

The effect of susceptibility bias in this study would result in an over-estimation of the odds of dying associated with the use of ALS. The beneficial impact of ALS in reducing mortality may have been confounded by the fact that the patients receiving ALS were at a higher risk of dying compared to the patients who received BLS only. Miettinen has called this phenomenon confounding by indication (Miettinen,1985:40).

Schlesselman states that correcting for susceptibility bias is achieved by controlling for the indication for the treatment in the analysis. Hence, if a specific treatment is prescribed to groups of patients because of the presence of a particular condition, then controlling for that condition in the analysis should alleviate the effect of the bias (Schlesselman,1982:142). In this study, allocation bias was caused because ALS was provided to patients with specific characteristics which are indicative of severe injury. Assuming that the ISS and the other variables that

were associated with mortality in the study provide a valid representation of these indicators, then controlling for these factors should reduce the effect of the susceptibility bias.

The main results in our study regarding the association between ALS and odds of dying were derived from logistic regression analysis, controlling for injury severity (ISS) and all other potential predictors of mortality. Therefore, to the extent that these variables are accurate measures of injury severity and reflect the indication for the use of ALS, the effect of susceptibility bias in these results should be reduced.

5.3.3.2. Selection Bias

Selection bias occurs in case-referent studies when the probability of being selected for the study sample is not the same for exposed and unexposed cases and referents (Anderson et al.,1980:40). This happens when the selection of subjects is not solely on the basis of outcome (cases or referents) but on the basis of exposure as well. Self-selection or other means of differential diagnosis, surveillance or referral may result in selection bias (Schlesselman,1982:131). The result of the selection bias is a distorted estimate of the effect which may be different from that obtained if the entire target population was used for the study. Therefore, any sampling procedure which may result in the selection of unequal proportions of exposed

and unexposed cases and referents may effect the estimates (Rothman,1986:83).

The effect of the selection bias can be assessed if the sampling fractions of the exposed cases (fa), exposed referents (fb), unexposed cases (fc), and unexposed referents (fd) are known (Kelsey et al.,1986:95-100; Schlesselman,1982:129). When these cannot be estimated, the study design should avoid unequal sampling, especially with respect to exposure. In fact, the effect of selection bias is greatest when the sampling fractions differ for both outcome and exposure (Kelsey et al.,1986:95-100). When sampling is necessary, it should be based only on outcome. If this is not possible, bias may be reduced if 100% of the cases are selected. Thus the biased selection of exposed or unexposed cases is eliminated (Anderson et al.,1980:40; Schlesselman,1982:131).

In the current study, selection bias may have been introduced by the sampling procedures leading to Sample I and Sample II which were outlined in Section 3.2.4. To recapitulate this sampling, first, all calls for which an MD was present at the scene as well as all calls for which the nurse requested an MD were screened in the first sampling phase. However, only 7% of the calls for which the nurse did not request an MD were screened. This sampling procedure caused the probability of being selected in the study for the patients being treated by an MD to be higher than that of the patients being treated only by an EMT. The

fact that all patients who were treated by an EMT received only BLS this introduced unequal sampling with respect to the exposure or treatment variable (ALS/BLS)

The next phase of sampling involved selection of patients to be followed to the hospital. The selection was based on the Pre-Hospital Index (PHI) scores for patients treated by an MD. A random 10% sample of patients not seen by an MD was followed to the hospital. Thus, the proportion of patients included in the second sample that were treated by EMTs only was further reduced. This increased the discrepancy between the fractions of the two treatment groups that had a chance of being included in the final study sample.

The probability for selection bias in this study may have been increased because, in addition to the unequal sampling of patients treated by ALS and BLS, not all potential cases were included. Patients who were treated by only an EMT that would have been subsequently classified as cases may have been excluded. This is especially true for the patients for whom an MD was requested by the nurse but one was not dispatched. Only 10% of these patients were followed to the hospital. Even more cases may have been missed from the group of patients for whom the nurse did not request an MD, especially from the patients in this category for whom the EMT may have requested an MD but one was not available. Only 0.7% of the patients for whom an MD was not requested and one was not dispatched were sampled.

Potential cases may also have been missed amongst the patients who were treated by an MD. Of these patients, (100%) with severe trauma (PHI > 3) and a random 10% sample of those with mild (PHI ≤ 3) trauma were followed to the hospital. It is possible that patients with mild trauma according to this classification would have been "cases" but were not included in the study.

The preceding discussion has suggested that selection bias may have been introduced through the unequal sampling of patients treated by ALS or BLS, and by the exclusion of potential cases from the final sample.

The question that follows concerns the direction and the extent of the bias. According to Schlesselman, sampling of only a fraction of the cases may result in over-exposure in the cases and an over-estimate of the risk (Schlesselman, 1982:131). However, the precise effect of the bias can be assessed either quantitatively, by estimating the sampling fractions or qualitatively, by examining the sampling and its effects on the composition of the study sample.

In the current study, the purpose of the sampling was to select trauma patients who were appropriate for the evaluation of trauma care. As was mentioned in previous chapters, these patients should have severe but non-fatal injuries. Therefore, the intent of the sampling was to remove all patients with minor trauma and those with non-survivable injuries. The resulting sample would therefore be representative of the patients with severe but

salvageable injuries.

The algorithms followed by the nurse at Urgences-Sante require that an MD be requested for all cases with potentially severe trauma. In addition, when an EMT was dispatched alone and the patient had sustained severe injuries, the EMT requests an MD. The assumption then was that the patients who were treated by an MD were more severely injured than the patients treated by an EMT. Therefore, we expected that by predominantly focusing on the patients treated by an MD, we would capture the majority of the severe trauma victims and therefore most of the fatalities. The data in Table 5.2 support this assumption by showing that among the patients followed to the hospital, a higher proportion of those treated at the scene by an MD had surgery or were admitted in an ICU. In addition, 19% of the 614 patients treated by an MD at the scene died compared to only 0.6% of the patients treated by an EMT only. These data show that although selection bias may operate, it would not seriously effect the study result in view of the low probability of excluding severely injured patients.

A method of assessing the effect of selection bias on the estimated parameters has been proposed by Kelsey et al. (1986:95-100), and Schlesselman (1982:129-131). By this method the impact of the selection bias is determined by (fa * fd)/(fb * fc) where fa = sampling fraction of exposed cases, fb = sampling fraction of exposed referents, fc = sampling fraction of unexposed cases, and fd = sampling fraction of unexposed referents. The estimation of these

sampling fractions for the present study is shown in Appendix E. Applying the above formula to these fractions results in a value of 1.755. This indicates that sampling bias does operate in this study, and that the effect of this bias is to overestimate the odds ratio associated with ALS. Schlesselman (1982:129), shows that the population odds ratio is given by $Y = Y^1/b$, where: Y = population odds ratio, Y^1 = estimated odds ratio and b = (fa * fd)/(fb * fc). In our study the crude odds ratio of dying associated with treatment by ALS was 5.17, applying the above mentioned formula results in an estimated population odds ratio of 3.00 (95% CI = 2.14 - 4.20).

Therefore, although selection bias was present, these results show that the effect of this bias does not completely explain the observed results. The magnitude of the odds ratio was reduced after accounting for the effect of the bias; however the resulting odds ratio continued to indicate a significantly increased odds of dying associates with treatment by ALS.

The preceding discussion has addressed the issue of the effect of potential selection bias on the results of this study. The effect of this bias is to overestimate the association between ALS and increased risk of dying compared to the true population risk, i.e. compared to the estimate of the relative risk that would have been obtained if the entire population was used.

However, as was mentioned in Chapter 1, pre-hospital trauma care will have the highest impact on the outcome of a specific subset of trauma patients. These patients are those with severe but survivable injuries. The outcome of patients with fatal injuries and of patients with minor injuries will not be affected by the quality of emergency care as the first will generally die and the latter will generally survive regardless of the quality of care.

Because the majority of trauma patients have minor injuries and only approximately 10% sustain severe trauma, by including all trauma victims in an evaluative study the beneficial impact of the intervention will be overestimated. It is therefore appropriate to select subjects for whom the quality of emergency care will have an impact on the outcome. This was the purpose of the sampling in the current study. The results shown in figure 5.1 confirm that the sampling was successful in selecting patients with injuries of intermediate severity. These are the patients for whom pre-hospital care may substantially affect the outcome.

As a result, although selection bias may cause the association between ALS and the odds of dying observed in this study to be overestimated compared to the overall population association, it was obtained from data on patients for whom pre-hospital care is important. This estimate may therefore be a more accurate representation of the effectiveness of ALS in reducing the odds of dying for

the subset of patients for whom emergency care may be important. On the contrary, the association obtained by using the entire population of trauma patients may have been biased in favour of ALS by the inclusion of patients with a high likelihood of surviving. This would be particularly true if ALS was provided to patients with minor injuries whether it was indicated or not. The probability of this occurring is high as reported by Luterman et al. (1983).

The sampling procedures introduced in the study may have affected our mortality comparison results. Because the sampling of our study was aimed to select patients with severe injuries, our sample was not comparable to that of the Major Trauma Outcome Study with respect to injury severity and case mix. This occurred because the mortality comparison was not one of the original objectives of the study. Therefore the sampling procedures were developed without considering their effect upon this outcome. This issue will be discussed in the next section.

5.3.3.3. Comparability with the MTOS Population

One of the important issues associated with the use of indirect standardization is the comparability between the standard and the study population, especially with respect to the standardization parameter. In the present study indirect standardization was performed using data from the MTOS population as published by Copes et al. (1988). The

purpose of the standardization was to compare the mortality rate in our study sample to that expected based on the ISS, patient age, and type of injury according to the experience of the patients in the MTOS study. Because parameters other than the ISS are also significantly associated with mortality, the comparability of our sample and the MTOS population with respect to these parameters should be evaluated. The results are shown in Table 5.3.

In our sample, 131 (37%) of the patients were involved in an MVA and only 66% of these survived, compared to the patients in the MTOS where 26% of the patients were involved in MVA and 93.5% of these survived. Although the proportions of motorcycle accident victims were similar for the two samples, only 50% of such patients in our study survived compared to 92.1% in the MTOS sample.

A higher proportion of pedestrians struck by automobiles was observed in the current study (17%) compared to the MTOS (7%). The survival rate in such pedestrians was lower for the current study (65%) compared to the MTOS (89.2%). Although only 5% (19) of the patients in our sample were gunshot victims compared to 11% of those in the MTOS, only 58% of these patients in our study survived compared to 84.9% of gunshot victims in the MTOS. Finally, among the victims of falls, there were 95.4% survivors in the MTOS compared to 81% in our sample.

These data suggest that the patients in our sample have more severe injuries when compared to those of the MTOS as indicated by the lower survival rates in Table 5.3.. This observation is most probably due to the fact that the sample in the current study consisted of selected severely injured patients, and did not include all the trauma patients transferred to Montreal hospitals. The MTOS sample, on the other hand, includes all trauma patients who are admitted or who die after arriving at the participating hospitals.

This is further confirmed by Figure 5.1. which shows that, compared to the MTOS sample, the sample of the present study had a higher proportion of patients with mid range ISS scores (ISS = 8 - 45). This again is as expected because our sampling was aimed at selecting patients with severe but survivable injuries and these injuries are represented by these ISS values. These data, however, also demonstrate that our selection process was successful in refining our sample to represent this subset of patients.

In addition to the differences in the case-mix and injury severity between MTOS population and our study, there exists a methodological difference in the way data for ISS score were collected for the two samples. The data collection method for the MTOS involved the use of forms containing information on demographics, etiology of injury, patient physiology at the scene and one hour after admission, detailed description of injures from physician

evaluation, and any other sources including radiology, surgery or autopsy. These forms were completed for every trauma patient and were included in the patient chart. This method reduces the possibility of omitting crucial information regarding the patient and the injury.

In contrast, data in our study were obtained retrospectively by a chart review, thus relying on only the information that was recorded by the attending physician or hospital personnel. In addition, autopsy reports were not reviewed as they are not routinely included in patient charts. As a result, the completeness of the data in our study may be inferior to that of the MTOS sample. This may be especially true for patients who died shortly after being brought to the hospital. More extensive data were probably accumulated for patients who remained in the hospital longer or survived and were assessed by radiologic or other means or had surgery or were admitted in an ICU. Because lack of information or detailed information results in reduced ISS ratings (injuries lacking sufficient detail are assigned low scores according to the AIS manual), the lack of complete data in our sample may actually result in an underestimation of the true ISS. As a result, the number of expected deaths in this sample has been underestimated. The degree of this underestimation may be larger if the underscoring of the ISS is more prominent in the patients who died.

In summary, the differences between the MTOS and our

sample with respect to injury severity, case-mix and methods of data collection may have caused an overestimation of the standardized mortality rate.

Theoretically, the difference in injury severity should have been adjusted by the standardization process, although the success of this may have been limited by the validity of the ISS in predicting mortality. The underestimation of the ISS in our study caused by incomplete data will be evaluated by an extensive chart review by which the validity of the ISS and the probability of survival will be determined for each patient individually. Although an underestimation of the ISS is expected it is not likely that it will be such that it would affect the direction of the results. The most probable impact will be with respect to the magnitude only.

Although these limitations must be recognized, it should be noted that the standard population used in this study is probably the best available at this point. The data were drawn from over 14,000 patients and the authors published specific probabilities of death for each age category, injury type, and ISS value. This approach was preferred to that of an equation or model in recognition of the inability of the ISS to accurately predict mortality via a direct mathematical function. Furthermore, although the ISS itself has limitations, it is the best measure of anatomical injury severity currently available.

Any underestimation of the ISS in this study should affect the magnitude of estimate of the standardized mortality rate for the entire sample and for the specific groups. However, this underestimation of the ISS should be uniform for all groups. Therefore the comparisons between groups with respect to the standardized rates are considered as reliable.

5.4. Strengths of the Study

5.4.1. Design Features

This was an observational study in which data on trauma patients serviced by Urgences-Santé during a one-year period were collected. There were no restrictions with respect to the type of trauma or the hospitals to which the patients were transferred. Therefore, generalizability of the results is not limited to certain injury types or to patients who were cared for in specific hospitals.

Patients were enrolled in the study in a prospective manner. All data were prospectively obtained with the exception of the ISS data which were retrospectively abstracted from hospital charts. The prospective design allowed the precise documentation of all the sampling procedures, and the effect of the sampling on the constitution of the final sample was determined. In addition, the presence and assessment of any bias introduced by the sampling was evaluated.

Furthermore, data on variables potentially related to the outcome or to the treatment were collected. When available, data on the mechanism of injury, body regions injured, and demographics were obtained. Data on injury severity and comorbidity were also collected. Thus, all information necessary to control for potential confounding was available.

The sampling procedures used in this study were carefully implemented so that the study sample would represent the population of trauma patients for whom the quality of emergency care could have a significant impact. A sample of patients with less severe injuries was also included so that the spectrum of injury severity was complete.

The potential of introducing bias by the uneven sampling of patients treated by an MD was recognized. However, the requirement of treatment by an MD indicated severe trauma and the decision was made to focus on patients in this category. This was done in order to identify the majority of severely injured patients, thus restricting our sample to those patients for whom the quality of pre-hospital care would have an important impact. Therefore, although any estimate of impact of pre-hospital care may have been biased when compared to an overall population estimate, it would be a reliable estimate for the effectiveness of ALS in the appropriate trauma patients.

5.4.2. Analysis Features

Two analytic methods were used in this study. First, standardized mortality ratios obtained by standardization to the MTOS sample were used to evaluate the impact of the Urgences-Santé emergency medical system as a whole and the pre-hospital and in-hospital components on trauma-related mortality. Statistical methods taking into consideration the small number of events contributing to the standardized ratios were used to evaluate the significance of individual SMRs and differences between SMRs of groups. Multivariate analysis controlling for other predictors of mortality was also used to assess the independent impact of the pre-hospital care and in-hospital emergency care on the standardized mortality ratios.

The effect of ALS on the odds of dying was evaluated using univariate, stratified bivariate and multivariate analysis. The use of these methods allowed control for the confounding that may have been introduced by the limitations of the study design.

5.5. Comparison with Other Studies

In spite of its potential limitations, the results of the present study are in agreement with other studies reported in the literature. Our findings of increased scene and total pre-hospital time associated with the use of ALS is in agreement with the results of Gervin et al. (1982),

Ivatury et al. (1987), Cayten (1984), Tsai et al.(1987), and Smith et al. (1985).

The failure of ALS to demonstrate a beneficial impact on trauma-related mortality is also supported by data reported by Gervin et al. (1982), Ivatury et al.(1987), Cayten (1984), and Tsai et al. (1987). Our findings of significantly higher number of observed than expected deaths in the patients treated by ALS compared to patients treated by BLS is similar to that reported by Cayten (1984).

In Montreal, although a pre-hospital system is in operation and hospitals offer a high level of care to severely injured patients, trauma care is not integrated in a single system and hospital based trauma care is not regionalized. The observed excess trauma-related mortality in our study although potentially overestimated, is in agreement with data reported by Lowe et al. (1983), Bolta et al. (1986), Kreis et al. (1986), indicating that lack of regionalization and trauma care system implementation results in excess mortality. Furthermore, the finding of excess mortality is in concordance with West et al. (1979), Cales (1984), Shackford et al. (1986), Guss et al. (1989), and Mullner et al. (1977), who have shown that implementation of trauma cares systems and regionalization of hospital trauma care reduces trauma-related mortality. Our finding of a reduced mortality in ACS level I compatible hospitals is also in agreement with these studies and

particularly with these of Kreis et al. (1986), Haller et al. (1983), Cales (1984), Trunkey (1983), who showed reduced mortality in level I trauma centres compared to non-specialized hospitals. Finally, our finding of a significant association between increased mortality and total pre-hospital delays exceeding 60 minutes is consistent with the "Golden Hour" principle of trauma care (Trunkey,1983; Boyd et al.,1984).

The results of our study also showed an increased mortality risk associated with motor vehicle accidents (MVA) and gunshot injuries, which is in agreement with the results of Kraus et al. (1988), Baker et al. (1985) and Waller et al. (1985). In our study increasing age was associated with increased risk of dying. Although this finding was not statistically significant, it is in agreement with the conclusions of Baker et al. (1976), Bull (1975), Naughton et al. (1988), Goldberg et al. (1983), and others (Lokerberg et al.,1984; Convoy et al.,1988; Kraus et al.,1985).

The higher mortality risk associated with head injuries which was found in our study is in agreement with the results of previous studies (Convoy et al.,1988; Baxt et al.,1987; Oreskovich et al.,1984; Osler et al.,1988; Naughton et al.,1988; Shimazu et al.,1983). Finally, our results also showed that the presence of pre-existing chronic conditions was associated with increased odds of dying, which is in agreement with Goldberg et al. (1983), and Morris and Mackenzie (1990).

5.6. Significance of the Study

The results of this observational study provide significant knowledge in the area of emergency trauma care. This study used data collected prospectively in an emergency medical system of a large North American city. The use of on-site physicians to provide ALS in such a setting is unique in North America, and potential problems associated with the use of EMTs such as deficient communication or lack of adequate training are not relevant.

The use of on-site physicians eliminates the need for long-distance communication between the on-site health provider and a control centre, and furthermore allows the physician to obtain a global or gestalt impression of the patient's condition. These features should optimize the efficiency of the on-site care.

However, it could also be argued that the ALS provided by well-trained EMTs who have had extensive experience may be of better quality than that provided by less specialized MDs. The physicians employed at Urgences-Santé are not trained traumatologists, and they are occasional employees at Urgences-Santé. Their background and experience, therefore, varies as does their approach to the treatment of severe injuries. At this point, we do not have the necessary information to evaluate the quality of pre-hospital care provided by the Urgences-Santé physicians. There is no evidence, however, to suggest that it is not

comparable to that in other North American emergency medical systems.

The results of this study have failed to demonstrate that ALS as provided by the Urgences-Santé physicians produced a reduction of the observed excess mortality in the severely injured patients of this study. The data from this study also demonstrated that while controlling for factors significantly prognostic of mortality, the use of on-site ALS was not more effective in reducing the risk of dying when compared to BLS only. In addition, the use of ALS significantly increased the time spent at the scene and consequently increased the delay to definitive medical care.

In this study, pre-hospital delays of more than 60 minutes were associated with a significantly high excess mortality while controlling for other prognostic factors including level of on-site care. This finding is significant in that it further supports the "Golden Hour" principle of trauma care, and further emphasizes the need for expeditious transport of patients to a facility capable of providing definitive care. These data also show that the most important factor in reducing trauma mortality is time to definitive care and that the level of on-site care is not associated with this outcome.

These findings support the "Scoop and Run" side and oppose the "Stay and Stabilize" approach for the pre-hospital management of severely injured patients. This

study used a case-referent approach to describe the association between ALS and mortality while identifying the specific study limitations and either assessing or controlling for their effects. These methods add validity to our results although results from future studies utilizing rigorous epidemiologic designs will be required to finally resolve this controversy.

An important finding of this study is the association between the level of trauma care available at the receiving hospital and the outcome of the injury. The group of patients that was treated in hospitals which are affiliated with medical schools and provide continuous emergency room and surgical care (ACS-compatible level I or II) had lower rates of excess mortality and a lower odds of dying when compared to the patients who were taken to local hospitals with minimal surgical or emergency care (ACS-compatible level III).

These results are significant in that although the ACS-level I or II compatible hospitals in our study are not designated or organized as trauma centres, the availability of adequate care improved the outcome in the severely injured patients. These findings further support the belief that severely injured patients are best cared for in specialized facilities such as trauma centres. Patient triage protocols calling for the transfer of severely injured patients to specialized hospitals are equally

necessary.

The two important findings in this study are that excessive time to definitive care is significantly associated with increased mortality and that the availability of high level of trauma care in the receiving hospital is associated with reducing mortality. The significance of these results is that both of these factors are modifiable. The designation and organization of trauma centres in the Montreal region could improve the level of trauma care available to severely injured patients. The implementation of patient triage protocols, regionalization of trauma care hospitals, and establishment of communications between ambulances and receiving hospitals will reduce total pre-hospital time while improving the efficiency of the pre-hospital and in-hospital emergency services.

In summary, although the results of this study did not resolve the controversy regarding pre-hospital trauma care, they provided some suggestive evidence supporting the "Scoop and Run" side while identifying and attempting to correct innate limitations of evaluative studies in this area. The significant findings of this study were that excessive pre-hospital delays and inadequate in-hospital trauma care result in excess mortality. These findings suggest that there exists a need for organization and regionalization of trauma care in the Montreal area.

5.7. Generalizability of Results

This study used data on a sample of trauma patients for whom pre-hospital care was provided by Urgences Santé. This sample represents the patients for whom Urgences-Santé was called and the patient was attended by an EMT or MD employed by this organization. However, this study does not comprise all Montreal area trauma victims injured during the study period.

Trauma victims may have been brought to Montreal hospitals by means other than Urgences-Santé ambulances. Such means may have been by private automobiles, other ambulance companies serving regions not covered by Urgences-Santé, police, or patients may have arrived at hospitals on their own accord. Our study did not obtain samples or data from these patients.

The generalizability of any study on trauma is often compromised by the lack of adequate coverage encompassing all potential sources of trauma victims. Several studies focus on specific mechanisms of injuries such as motor vehicle accidents, while others concentrate on patients in a single hospital. This is because of the difficulty to monitor all potential sources of trauma victims, especially in view of the fact that the classification or diagnosis of injury or trauma is generally not standardized or reported in any comprehensive manner. As a result, the possibility of missing trauma cases cannot be avoided.

In this study, the source of trauma victims was Urgences-Santé. Our results therefore can be generalized to this population of trauma patients. However, it is quite probable that patients for whom Urgences-Santé was called are more severely injured than patients who were brought to hospitals by other means. At this point, we do not have the data to confirm this.

The results in this study concerning the association between ALS and the odds of dying were obtained for patients receiving on-site care by a physician. This situation is substantially different than that in most emergency medical systems where on-site care is provided by trained EMTs. The comparability of care provided by the Urgences-Santé physician and that provided by EMT's of other systems could not be evaluated. Therefore, these results can be generalized to the patients treated by Urgences-Santé. However, the paradigm concerning the association of ALS and mortality from this study provides valuable knowledge in the area.

5.8. Recommendations for Further Research

The results of this study have suggested excess mortality in severely injured patients cared for by Urgences-Santé in the Montreal area. The ISS was the principal standardization variable used to determine expected deaths and the level of excess mortality. However,

limitations of the ISS in general and potential insufficiencies of the ISS data in our study were identified. These may have caused underestimation of the ISS and of the expected deaths and therefore overestimation of the excess mortality. The validity of the ISS value and the likelihood of survival should be determined by a careful review of the charts of the final sample. This will allow validation of the excess mortality observed in this study.

This study failed to demonstrate an association between the use of on-site ALS and mortality or risk of dying. Although the potential effect of selection bias was assessed and multivariate statistical methods were used to control for the effect of susceptibility bias in this study, further studies using larger samples and designs less prone to biases should be conducted. The accumulation of data from such studies is necessary to eventually resolve the "Scoop and Run" versus "Stay and Stabilize" controversy regarding pre-hospital trauma care.

Our study showed a lower excess mortality and reduced risk of dying in hospitals with high level trauma care. However, significant excess mortality was observed for all levels of hospital care. The present study did not obtain detailed data on the course of events following arrival at the hospital. Data on the time between arrival of the patient and first contact of the physician, final assessment and definitive care, especially surgery were not obtained

and are necessary to further evaluate the quality of in-hospital care. These data would provide suggestions for further improvement in trauma care and may explain at least partially the observed excess mortality in our study.

5.9. Summary

The purpose of this observational study was to describe and evaluate emergency trauma care in Montreal. Data on trauma victims serviced by Urgences-Santé were prospectively collected during a one-year period. Standardized mortality ratios based on data from the MTOS sample were used to assess the mortality in a sample of severely injured patients. Comparison of standardized ratios between patient groups was used to evaluate the impact of pre-hospital and in-hospital care on mortality from severe injuries. An unmatched case-referent design was used to estimate the association between on-site ALS and odds of dying in a sample of severely injured patients.

The descriptive part of the study showed that approximately 20,000 calls requesting assistance for trauma were received by Urgences-Santé during the one-year period between April 1,1987 and March 31,1988. An MD was requested by the Urgences-Santé nurse for an estimated 6200 of these calls and an MD was dispatched for 76% of these. An EMT only was requested for approximately 14,000 of the calls, and for 6% of these an MD was subsequently requested by the

EMT. Although the response, scene, and hospital transport times of Urgences-Santé were comparable with those of other large North American cities, the presence of an MD at the scene and the use of ALS were significantly associated with increased scene and total pre-hospital times.

The results of this study showed that the use of ALS did not reduce excess mortality and was not associated with reduced risk of dying in severely injured patients. Pre-hospital time exceeding 60 minutes was significantly associated with both increased excess mortality and increased risk of dying. A significant trend towards reduced standardized mortality rates was observed with higher levels of in-hospital trauma care. Higher level of in-hospital trauma care was also associated with reduced risk of dying.

Study limitations including selection and susceptibility biases, as well as the potential reduced reliability in measuring injury severity were identified. These limitations may have influenced the magnitude of estimates of excess mortality or of the association between ALS and odds of dying. However, statistical methods were used to control for the effect of susceptibility bias. The estimated effect of the selection bias indicated that it is not likely to significantly account for the observed association between ALS and odds of dying. Furthermore, the effect of the selection bias may be partially compensated by

the fact that this study focused primarily on the trauma victims with severe but survivable injuries. Finally, the underscoring of the ISS may have influenced the magnitude of the standardized mortality ratios but not the comparison between groups with respect to this outcome.

The results of our study are in agreement with several other studies showing that ALS is associated with increased pre-hospital times and is not associated with a reduction in the risk of trauma-related mortality. Our findings of increased odds of dying associated with excessive pre-hospital times and inadequate in-hospital trauma care are also in agreement with the "Golden Hour" principle for trauma care. Numerous other studies have also shown that care in specialized trauma care facilities reduces trauma-related mortality.

This observational study on the evaluation of pre-hospital trauma services in Montreal has suggested that regionalization of trauma care and organization of Montreal hospitals as trauma centres may contribute to reduction in trauma-related mortality. Integration of Urgences-Santé and hospital emergency services into a single system may reduce pre-hospital times and also contribute to reduced mortality. Further research is required to evaluate the effectiveness of on-site ALS in reducing mortality from severe injuries.

5.10. Conclusions

The conclusions of this study are the following:

1. The response and total pre-hospital times of Urgences -Santé ambulances are comparable to those of other North American emergency medical systems.

2. The presence of a physician at the scene of an accident is associated with a significant increase in on the scene and pre-hospital total time. The use of advanced life support procedures is also associated with significant increases in on scene and total pre-hospital times.

3. The use of advanced life support procedures by Urgences-Santé physicians failed to demonstrate an association with reduced mortality in severely injured patients.

4. Pre-hospital times exceeding 60 minutes were significantly associated with increased mortality in severely injured patients.

5. Treatment in ACS level I compatible hospitals was significantly associated with decreased mortality and reduced risk of dying in severely injured patients.

Table 5.1 Comparison with Other Studies.

Location	System	N	Year	Mean Times (minutes) Response	Scene	Travel	Total
San Diego	ALS-Land	150	1983	7 0	18.0	10 0	35 0
	ALS-MD-Air	150	1983	10.0	24 0	24 0	58 0
Washington D.C.	ALS	163	1980	4.8	24.9	19 4	49 1
Denver	ALS	114	1984	5 6	13 9	8 0	27 5
South Carolina	ALS	435	1983	7 4	24 8	14 4	46 6
	BLS	102	1983	7.4	18.9	15.8	42 1
Bronx	ALS	100	1986	4.5	11 8	5 5	21 8
Denver	ALS	100	1985	4 5	10 1	6.4	21 0
Montreal	ALS+BLS	8007	1987	5.4	18 8	9 7	33 9

Table 5 2 Course of Hospitalization by Presence of MD at Scene (Sample II, N = 928).

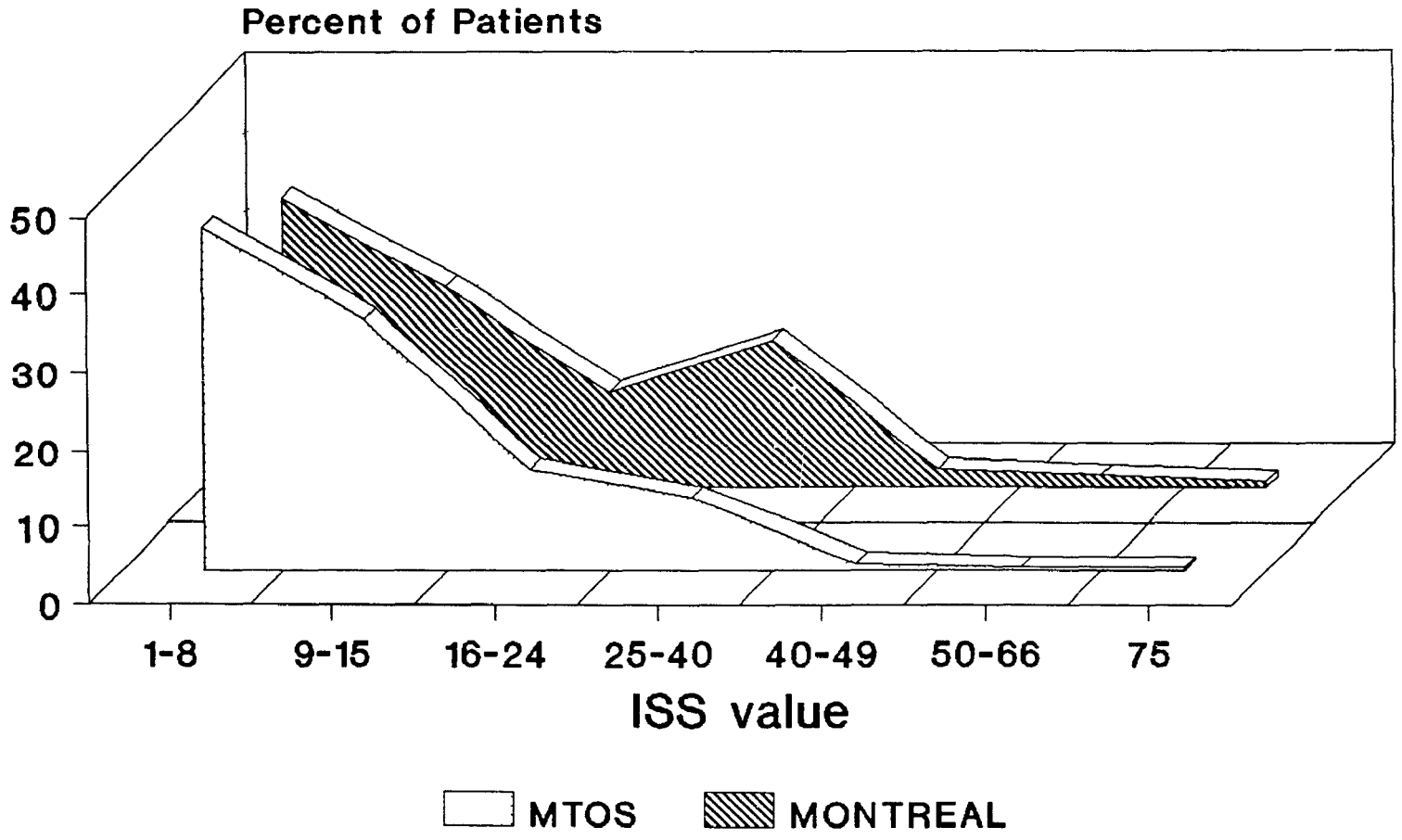
	N (%)		
In-Hospital Care	Total	EMT + MD present	EMT only
N	928	614	314
None	539 (58)	285 (46)	254 (81)
Admission only	74 (8)	59 (9)	15 (5)
Surgery only	7 (0.75)	5 (1.6)	2 (0.3)
ICU only	5 (0.5)	5 (0.8)	0 (0)
Admission & Surgery	91 (10)	64 (10)	27 (9)
Admission & ICU	42 (5)	39 (6)	3 (1)
Admission, Surgery & ICU	58 (6)	50 (8)	8 (3)
Mortality	117 (13)	115 (19)	2 (0.6)

Table 5 3. Comparison of Current Study Sample with MTOS

		Current Study	MTOS*	
Variable	N (%)	Survive (95% CI)	(N (%)	Survive (95% CI)
MVA	131 (37)	66 (57 - 74)	3916 (26)	93 5 (92 - 94)
Motorcycle	14 (4)	50 (23 - 76)	961 (6)	92 1 (90 - 94)
Pedestrian	62 (17)	65 (53 - 76)	1039 (7)	89 2 (87 - 91)
Gunshot	19 (5)	58 (35 - 80)	1589 (11)	84 9 (83 - 87)
Stabbing	61 (17)	93 (86 - 99)	1814 (12)	96 4 (95 - 97)
Fall	53 (15)	81 (70 - 91)	2736 (18)	95 4 (94 - 96)

* (Copes,1988)

Figure 5.1 Distribution of ISS for MTOS (N=14876) and Montreal (N=360) Samples



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APPENDICES

APPENDIX A

Comparison of Treatment Groups

Table A.1 Demographic Characteristics of Treatment Groups (Sample III, N = 360).

Variable	Total	ALS	BLS	
N	360	239	121	
Age (yrs)				
Mean	33 9	34 6	32 5	t = 0 962
S.d	19 5	19 5	19 4	DF = 242 7
Median	29 0	29 0	28 0	p = 0 337
Range	0 - 84	1 - 84	0 - 82	

Age Category (yrs)	Total N (%)	Total Male (%)	ALS N(%)	ALS Male (%)	BLS N (%)	BLS Male (%)
0 - 15	46 (13)	50	26 (11)	46	20 (17)	60
16 - 30	142 (40)	80	99 (41)	83	43 (36)	74
31 - 45	85 (24)	75	55 (23)	71	30 (25)	83
46 - 60	43 (12)	67	27 (11)	70	16 (13)	62
> 60	44 (12)	55	32 (13)	53	12 (10)	58

Age $X^2 = 2\ 5$, DF = 4, p = 0 64

Gender $X^2 = 0\ 005$, DF = 1, p = 0 94

Table A.2 Comorbidity in Treatment Groups (Sample III, N = 360)

Pre-existing Condition (PEC)	Total	ALS	BLS	Odds Ratio* (95% CI)
N	360	239	121	---
Cardiovascular	9 (3)	5 (2)	4 (3)	0 6 (0.2 - 2.3)
Renal	3 (1)	2 (0.8)	1 (0.8)	0 1 (0 1 - 11.3)
Pulmonary	19 (5)	14 (6)	5 (4)	1.4 (0 5 - 4 1)
Diabetes	8 (2)	7 (?)	1 (0 8)	3 6 (0 5 - 26 0)
Cirrhosis	2 (0 6)	2 (0 08)	0 (0)	2 0 (0 1 - 42.7)
Cancer	3 (0.8)	0 (0)	3 (2)	0 08 (0.01 - 0.90)
≥ 1 PEC	44 (12)	30 (13)	14 (12)	1 1 (0.6 - 2.2)

* Crude adjusted Odds Ratio of being treated by ALS for PEC being present compared to PEC not being present

Table A.3 Injury Characteristics in Treatment Groups Location of Accident (Sample III, N = 360)

Location of Accident	N (%) Total	ALS	BLS	Odds Ratio* (95% CI)
N	360	239	121	---
Home	93 (26)	63 (26)	30 (25)	1 1 (0.7 - 1 8)
Workplace	13 (4)	11 (5)	2 (2)	2 9 (0 7 - 12 3)
Circulation (MVA)	131 (37)	108 (46)	23 (19)	3 5 (2 1 - 5 8)

X^2 = 92 9, DF = 4, p < 0 0001

Data on location of accident were missing for 54 subjects, and 69 accidents occurred in locations other than those specified

Abbreviations, MVA Motor Vehicle Accident

* Crude unadjusted Odds Ratio of being treated by ALS for accident occurring at the specific location compared to accident not occurring in the location

Table A 4 Injury Characteristics for Treatment Groups Mechanism of Injury (Sample III, N = 360).

Mechanism	Total N (%)	ALS N (%)	BLS N (%)	Odds Ratio* (95% CI)
N	360	239	121	---
Firearm	19 (5)	18 (7)	1 (1)	9 8 (1.9 - 5.2)
Stabbing	61 (17)	45 (19)	16 (13)	1 5 (0.8 - 2.8)
Falls	53 (15)	29 (12)	24 (20)	0 6 (0.3 - 1.0)
Electrocution	3 (0 8)	3 (1)	0 (0)	3 0 (0.2 - 53.1)
Hanging	7 (2)	7 (3)	0 (0)	7.3 (0.6 - 85 9)
Lacerations	25 (7)	20 (8)	5 (4)	2.1 (8.8 - 5 7)
Crushing	5 (1)	5 (2)	0 (0)	5.1 (0.4 - 70.6)
Fight	5 (1)	1 (0 4)	4 (3)	0 1 (0 02 - 0.8)
MVA				
Driver	25 (7)	23 (10)	2 (2)	6 3 (1 7 - 22 9)
Passenger	12 (3)	12 (15)	0 (0)	12.7 (1 4 - 116.3)
Motorcycle	14 (4)	11 (5)	3 (2)	1 9 (0.5 - 6.8)
Bicycle	12 (3)	8 (3)	4 (3)	1 0 (0.3 - 3.4)
Pedestrian	62 (17)	49 (20)	13 (11)	2.1 (1.1 - 4.1)

X^2 = 30 0, DF = 12, p = 0 0001

Abbreviations - MVA· Motor Vehicle Accident

* Crude unadjusted Odds Ratio of being treated by ALS for specific mechanism causing the injury compared to mechanism not causing the injury

Table A.5 Injury Characteristics for Treatment Groups Body Regions Involved (Sample III, N = 360).

Body Region	N (%) Total	ALS	BLS	Odds Ratio* (95% CI)
N	360	239	121	---
Isolated Head	23 (6)	21 (9)	2 (2)	5 7 (1 3 - 24 9)
Head	135 (37)	108 (45)	27 (22)	2 9 (1.7 - 4 7)
Chest	105 (29)	83 (35)	22 (18)	2.4 (1 4 - 4 1)
Abdomen	88 (25)	71 (29)	17 (14)	2 6 (1 4 - 4 6)
Extremities	151 (42)	96 (40)	55 (45)	0 8 (0 5 - 1 2)
Face	30 (8)	23 (10)	7 (6)	1 7 (0 7 - 4 2)
External	208 (58)	136 (57)	72 (59)	0 9 (0 6 - 1 4)
Number of Regions				
1	162 (45)	96 (40)	66 (55)	
2	114 (32)	74 (31)	40 (33)	X^2 = 16 4
3	54 (15)	41 (17)	13 (11)	DF = 4
4	15 (4)	13 (5)	2 (1)	p = 0 003
5	15 (4)	15 (6)	0 (0)	
> 1	198 (55)	143 (59)	55 (45)	1 8 (1 1 - 2 8)**
Penetrating Trauma	78 (22)	56 (23)	22 (18)	1 4 (0 8 - 2 4)***

* Crude unadjusted Odds Ratio for being treated by ALS compared to body region not being injured

** Crude unadjusted Odds Ratio of being treated by ALS for injuries to more than one body region compared to single region injuries

*** Crude unadjusted Odds Ratio of being treated by ALS for penetrating trauma compared to blunt trauma

Table A.6 Injury Characteristics for Treatment Groups Injury Severity (Sample III, N = 360).

ISS	Total	ALS	BLS	
N	360	239	121	
Mean	13 7	16 7	7 9	t = 6 8
S.d.	12 2	13 0	7 7	DF = 358
Median	10 0	14.0	5.0	p = 0 0001
Range	1 - 59	1 - 59	1 - 35	
TS				
N	103	86	17	
Mean	11.4	10 8	14.5	t = 6 1
S d	3.7	3.7	1 9	DF = 44
Median	12.0	11 0	15 0	p = 0 0001
Range	1 - 16	1 - 16	10 - 16	

	N (%)		
ISS Category	Total	ALS	BLS
N	360	239	121
0 - 14	230 (64)	127 (53)	103 (85)
15 - 24	45 (12)	34 (14)	11 (9)
25 - 59	85 (24)	78 (33)	7 (6)
≥ 15	130 (36)	112 (47)	18 (15)

X^2 = 39 1, DF = 2, p < 0.0001 [ISS 3 categories]

X^2 = 35 6, DF = 1, p < 0 0001 [ISS 2 categories]

Abbreviations, ISS· Injury Severity Score
TS Trauma Score

Table A 7 System Times for Treatment Groups (Sample III, N = 360)

Time Interval (min)	Total	ALS	BLS	
Response				
N	307	197	110	
Mean	7.6	7 8	7 3	t = 0 9
S.d.	4 9	4.7	5 1	DF = 211 3
Median	7.0	7.0	7 0	p = 0 37
Range	0 - 33	0 - 33	0 - 33	
Scene				
N	315	203	112	
Mean	20.0	22 1	16 2	t = 4 8
S d	10 4	9.4	10.9	DF = 202
Median	20.0	22 0	15 0	p = 0 001
Range	0 - 57	0 - 50	0 - 57	
Transport				
N	315	205	110	
Mean	7 7	7 8	7 4	t = 0 41
S d.	7.1	7 6	6 3	DF = 261
Median	6 0	6 0	6 0	p = 0 68
Range	0 - 57	0 - 57	0 - 28	
Total				
N	272	172	100	
Mean	35.6	38 2	31 1	t = 3 6
S.d.	15.3	13 9	16 6	DF = 179
Median	35 0	37 0	32 0	p = 0 0004
Range	0 - 84	0 - 84	0 - 74	

Data on Response Time were missing for 53 patients

Data on Scene and Transport Time were missing for 45 patients

Data on Total Time were missing for 88 patients

Response Time = Call to arrival of ambulance at scene

Scene Time = From arrival of ambulance at scene to departure

Travel Time = From departure from scene to arrival at hospital

Total Time = From call to arrival at hospital

Table A.8 Time from Call to Arrival at Hospital for Treatment Groups (Sample III, N = ~~300~~ 272).

Time Interval (min)	N (%) Total	ALS	BLS	
N	272	172	100	
0 - 15	22 (8)	6 (3)	16 (16)	X^2 = 20.6
16 - 30	69 (25)	37 (22)	32 (32)	DF = 4
31 - 45	124 (46)	89 (52)	35 (35)	p < 0 0001
46 - 60	44 (16)	32 (19)	12 (12)	
> 60	13 (5)	8 (5)	5 (5)	OR* = 0.93 95% C.I = 0 3 - 2.9
> 30	181 (67)	129 (75)	52 (52)	OR** = 2 8 95% C I. = 1 7 - 4 6

* Crude unadjusted Odds Ratio of total time > 60 minutes for being treated by ALS compared to BLS

** Crude unadjusted Odds Ratio of total time > 30 minutes for being treated by ALS compared to BLS

Table A 9 ACS-Classification Compatibility of Receiving Hospitals for Treatment Groups (Sample III, N = 360)

ACS Compatibility of Receiving Hospital	N (%) Total	ALS	BLS
I	158 (44)	111 (43)	47 (39)
II	109 (30)	79 (33)	30 (25)
III	93 (26)	49 (21)	44 (36)
Total	360	239	121

$X^2 = 10.7$, DF = 2, p = 0.005

APPENDIX B

Stratified Analyses for Association between On-site Care (ALS/BLS) and Odds of Dying

Table B.1 Stratified Odds Ratio for Treatment by ALS by Age Category (Sample III, N = 360)

Age Category	N	ALS Cases	ALS Referents	BLS Cases	BLS Referents	Odds Ratio (95% CI)
0 - 15	43	10	16	2	15	4 7 (0 9 - 25 0)
16 - 30	142	24	75	1	42	13 4 (1 8 - 102 9)
31 - 45	85	10	45	3	27	2 0 (0 5 - 7 9)
46 - 60	43	6	21	1	15	4 3 (0.5 - 39 4)
> 60	44	14	18	1	11	8 6 (0.9 - 74 4)

Mantel- Haenzel Adjusted OR : 5.1

95% CI 2 5 - 10.6

Table B.2 Stratified Odds Ratio for Treatment by ALS by Presence of Pre-existing Conditions (Sample III, N = 360)

	N					
		ALS		BLS		
PEC*	N	Cases	Referents	Cases	Referents	Odds Ratio (95% CI)
YES	44	10	20	1	13	6.5 (0.7 - 56.9)
NO	316	54	155	7	100	4 9 (2 2 - 11 4)

Mantel- Haenzel Adjusted OR 5 1

95% CI 2 5 - 10 5

*PEC Pre-existing conditions in any of the following categories· Cardiovascular, Renal, Pulmonary, Diabetes, Cirrhosis, Cancer

Table B.3 Stratified Odds Ratio for Treatment by ALS by Location of Accident (Sample III, N = 360)

Location of Accident	N	ALS Cases	ALS Referents	BLS Cases	BLS Referents	Odds Ratio (95% CI)
Home & Work	106	8	66	0	32	7 8 (0 7 - 92 7)
Circulation (MVA)	131	41	67	3	20	4 1 (1 1 - 14 6)

Mantel- Haenzel Adjusted OR 5 5

95% CI . 1 5 - 23 7

Table B 4 Stratified Odds Ratio for Treatment by ALS by Body Regions Injured (Isolated Head Injury) (Sample III, N = 60)

		N				
		ALS		BLS		
Isolated Head Injury	N	Cases	Referents	Cases	Referents	Odds Ratio (95% CI)
YES	23	9	12	0	2	3 0 (0 13 - 70 8)
NO	337	55	163	8	111	4 7 (2 1 - 10 2)

Mantel- Haenzel Adjusted OR 4 9

95% CI 2 4 - 10 1

Table B 5 Stratified Odds Ratio for Treatment by ALS by Body Region Injured (Head) (Sample III, N = 360).

		N				
		ALS		BLS		
Head Injury	N	Cases	Referents	Cases	Referents	Odds Ratio (95% CI)
none	225	14	117	2	92	5 5 (1 2 - 24 8)
AIS: 1 - 3	56	5	32	1	18	2 8 (0 3 - 26 0)
AIS. 4 - 5	79	45	26	5	3	1 0 (0 3 - 4 7)

Mantel- Haenzel
Adjusted OR : 2.8

95% CI 1 1 - 6 7

Table B 6 Stratified Odds Ratio for Treatment by ALS by Body Region Injured (Chest) (Sample III, N = 360)

	N	ALS		BLS		
Chest Injury	N	Cases	Referents	Cases	Referents	Odds Ratio (95% CI)
none	225	27	129	6	93	3.2 (1 3 - 8 2)
AIS 1 - 3	83	25	39	1	18	11 5 (1 5 - 91.9)
AIS 4 - 5	22	12	7	1	2	3 4 (0.3 - 44.0)

Mantel- Haenzel
Adjusted OR . 4.3

95% CI 2 0 - 9 0

Table B 7. Stratified Odds Ratio for Treatment by ALS by Body Region Injured (Abdomen) (Sample III, N = 360).

	N	ALS		BLS		
Abdominal Injury	N	Cases	Referents	Cases	Referents	Odds Ratio (95% CI)
none	272	40	128	7	97	4 3 (1 9 - 10 1)
AIS: 1 - 3	76	19	42	0	15	13 6 (1 4 - 133 3)
AIS. 4 - 5	12	5	5	1	1	1 0 (0 5 - 20 8)

Mantel- Haenzel
Adjusted OR : 4 9

95% CI : 2.4 - 10.4

Table B 8 Stratified Odds Ratio for Treatment by ALS by Body Region Injured (Extremities) (Sample III, N = 360).

Extremity Injury	N	N ALS Cases	N ALS Referents	N BLS Cases	N BLS Referents	Odds Ratio (95% CI)
none	209	40	103	5	61	4 8 (1 8 - 12 6)
AIS 1 - 3	149	23	71	3	52	5 6 (1.6 - 19.7)
AIS 4 - 5	2	1	1	--	--	---

Mantel- Haenzel Adjusted OR 5 1

95% CI 2.5 - 10 4

Table B.9 Stratified Odds Ratio for Treatment by ALS by Multiple Injury (Sample III, N = 360)

Number of Body Regions Injured	N	ALS N Cases	ALS N Referents	BLS N Cases	BLS N Referents	Odds Ratio (95% CI)
1	162	13	83	1	65	10 2 (1 3 - 79 9)
> 1	198	51	92	7	48	3 8 (1 6 - 9 0)

Mantel- Haenzel Adjusted OR	4 7
95% CI	2 2 - 9.8

Table B 10 Stratified Odds Ratio for Treatment by ALS by Type of Injury (Sample III, N = 360).

Type of Injury	N	N: ALS Cases	N: ALS Referents	N: BLS Cases	N: BLS Referents	Odds Ratio (95% CI)
Blunt	282	59	124	7	92	6 3 (2.7 - 14 3)
Penetrating	78	5	51	1	21	2 1 (0.3 - 18 7)

Mantel- Haenzel Adjusted OR 5 5

95% CI 2 7 - 11 2

Table B 11 Stratified Odds Ratio for Treatment by ALS by Injury Severity (ISS) (Sample III, N = 360)

	N					
		ALS		BLS		
ISS Category	N	Cases	Referents	Cases	Referents	Odds Ratio (95% CI)
1 - 14	230	4	123	1	102	3 3 (0 4 - 20 1)
15 - 24	45	11	23	2	9	2 1 (0 4 - 11 7)
25 - 59	85	54	29	5	2	0 7 (0 1 - 3 7)

Mantel- Haenzel
Adjusted OR · 1 57

95% CI 0.6 - 4 3

Table B.12 Stratified Odds Ratio for Treatment by ALS by Time to Arrival at the Hospital (Sample III, N = 360).

Time from Call to Hospital Arrival (min)	N	ALS N		BLS N		Odds Ratio (95% CI)
		Cases	Referents	Cases	Referents	
0 - 30	91	9	34	5	43	2.3 (0.7 - 7 4)
31 - 60	168	31	90	1	46	15 8 (2.1 - 12 0)
> 60	13	4	4	0	5	10.0 (0 5 - 199 6)

Mantel- Haenzel Adjusted OR 5 9

95% CI 2 5 - 14 3

Table B.13 Stratified Odds Ratio for Treatment by ALS by ACS-Classification Compatibility of Receiving Hospital (Sample III, N = 360)

Receiving Hospital ACS-Compatibility	N	N ALS Cases	N ALS Referents	N BLS Cases	N BLS Referents	Odds Ratio (95% CI)
I	158	29	82	2	45	7 9 (1 8 - 34 9)
II	109	25	54	2	28	6 5 (1 4 - 29 4)
III	93	10	39	4	40	2 6 (0 7 - 8 9)

Mantel- Haenzel
Adjusted OR 5 1

95% CI . 2 5 - 10 7

APPENDIX C

Multivariate Analyses
Logistic Regression Models

Table C.1 Multiple Unconditional Logistic Regression Model I On-site Care, Patient Characteristics and Injury Characteristics (Sample III, N = 860)

Variable	Coefficient	S E	Coefficient/ S E	Odds Ratio (95% C I)
Age	0.014	0 009	1 479	1 01 (0 99 - 1 03)
Gender	0 018	0 199	0 091	1 02 (0 69 - 1 50)
PEC	-0 011	0 270	-0 040	0 99 (0 58 - 1 68)
MVA	0.326	0 231	1 407	1 39 (0 88 - 2 18)
Headneck	0 193	0 265	0 727	1 21 (0 72 - 2 04)
Chest	0.110	0 217	0.509	1 12 (0 73 - 1 71)
Abdomen	-0.148	0 237	-0 624	0 86 (0 54 - 1 37)
Penetrating	0 351	0 356	0 986	1 42 (0 71 - 2 85)
Multiple	-0 021	0 258	-0 081	0 98 (0 59 - 1 62)
ISS	1 565	0 246	6 371	4 78 (2 95 - 7 75)
ALS	0 067	0 264	0 256	1 07 (0 64 - 1 79)

All variables dichotomous (0/1 NO/YES) with exception of

Age. Continuous, Gender 1 = M, 2 = F,

ISS· 3 categories (1/2/3 1-14/ 15-24/ 25-59),

ALS· Dichotomous (0 = BLS only, 1 = ALS)

Abbreviations PEC Pre-existing Conditions (Cardiovascular, Renal, Pulmonary, Diabetes, Cirrhosis, Cancer)

MVA Motor Vehicle Accident

ISS Injury Severity Score

ALS. Advanced Life Support

Table C 2 Multiple Unconditional Logistic Regression: Model II On-site Care, Patient Characteristics, Injury Characteristics, Interaction of On-site Care and Injury Severity (Sample III, N = 360).

Variable	Coefficient	S E	Coefficient/ S E	Odds Ratio (95% C I)
Age	0 013	0 009	1 402	1 01 (1.00 - 1 03)
Gender	0 015	0 199	0 074	1.02 (0 69 - 1 50)
PEC	-0 018	0 271	-0 068	0.98 (0.58 - 1 67)
MVA	0 326	0 232	1 409	1 39 (0 88 - 2.18)
Headneck	0 206	0 265	0 775	1.23 (0 73 - 2.07)
Chest	0.124	0 217	0 570	1.13 (0 74 - 1 73)
Abdomen	-0 131	0 236	-0.558	0.88 (0 55 - 1.39)
Penetrating	0 327	0 357	0 915	1 39 (0 69 - 2 79)
Multiple	-0 052	0 261	-0 199	0 95 (0 57 - 1 58)
ISS	1 699	0.313	5.427	5 47 (2.96 - 10.10)
ALS	0 719	0 913	0 788	2.05 (0 34 - 12 29)
ALS * ISS	-0 218	0 287	-0 760	0 80 (0 46 - 1 41)

~~Goodness of Fit X^2_{338} = 201 14; p = 1 00~~

All variables dichotomous (0/1 NO/YES) with exception of

Age Continuous, Gender 1 = M, 2 = F,

ISS 3 categories (1/2/3 1-14/ 15-24/ 25-59),

ALS Dichotomous (0 = BLS only, 1 = ALS)

Table C.3 Multiple Unconditional Logistic Regression
Model III: On-site Care, Patient Characteristics, Injury Characteristics (severity such individual body region ALS scores) (Sample III, N = 360)

Variable	Coefficient	S E	Coefficient/ S E	Odds Ratio (95% C I)
Age	0 014	0 095	1 420	1 01 (0 84 - 1 22)
Gender	-0.097	0 204	-0 476	0 91 (0 61 - 1 35)
PEC	0.079	0.285	-0 278	1 08 (0 62 - 1 89)
MVA	0 393	0 244	1 612	1 48 (0 92 - 2 39)
Headneck [1]	0.833	0 126	6 631	2 30 (1 80 - 2 94)
Chest [1]	0.586	0 134	4 382	1 80 (1 38 - 2 34)
Abdomen [1]	0.587	0 177	3 318	1 80 (1 27 - 2 54)
Extremities [1]	-0 361	0 170	-2 119	0 70 (0 50 - 0 97)
Face [1]	-0 376	0 266	-1 411	0 69 (0 41 - 1 16)
External [1]	0.029	0.359	0 083	1 03 (0 51 - 2 08)
Penetrating	-0 095	0 354	-0 267	0 91 (0 45 - 1 82)
Multiple	-0.043	0 285	-0 151	0 96 (0 55 - 1 67)
ALS	0 022	0 258	0 086	1 02 (0 62 - 1 69)

Goodness of Fit X^2_{342} = 202 6, p = 1 00

All variables dichotomous (0/1 NO/YES) with exception of

Age: Continuous, Gender 1 = M, 2 = F,

ISS. 3 categories (1/2/3 1-14/ 15-24/ 25-59),

ALS: Dichotomous (0 = BLS only, 1 = ALS)

1 AIS scores for each body region, Range (0 - 5)

Table C 4 Multiple Unconditional Logistic Regression
Model IV Patient Characteristics, Injury Characteristics,
Mechanism of Injury, On-Site Care (Sample III, N:360)

Variable	Coefficient	S E	Coefficient/ S E	Odds Ratio (95% C I)
Age	0 017	0 010	1 808	1 02 (1 00 - 1 04)
Gender	-0 209	0 213	-0 982	0 81 (0 53 - 1 23)
PEC	-0 003	0 283	-0 012	1 00 (0 57 - 1 74)
Headneck	0 317	0 269	1.178	1 37 (0 81 - 2.33)
Chest	0 314	0 223	1 408	1 37 (0 09 - 21 62)
Abdomen	-0 138	0 234	-0 589	0 73 (0 46 - 1 15)
Multiple	0 118	0 262	0 451	1 12 (0 67 - 1 88)
ISS	1 745	0 291	5 998	5 73 (3 24 - 10 13)
Home	-0 382	0 292	-1 308	0 68 (0 38 - 1 21)
Gunshot	0 979	0 389	? 516	2 66 (1 24 - 5 71)
Stabbing	0 175	0 381	0 450	1 10 (0 56 - 2.51)
Laceration	0 523	0 599	0 872	1 69 (0 52 - 5 46)
Motorcycle	0 634	0 418	1 517	1 88 (0 83 - 4 28)
Pedestrian	0 177	0 249	0 712*	1 19 (0 73 - 1 95)
Fight	-2 381	0 000	0 000	0 09 (0 09 - 0 09)
Driver	0 333	0 382	0 871	1 39 (0 66 - 2 95)
ALS	0 114	0 271	0 421	1 12 (0 66 - 1 91)

Goodness of Fit X^2_{336} = 199 3, p = 1 00

Table C 5 Multiple Unconditional Logistic Regression
Model V. Patient Characteristics, Injury Characteristics,
On-site Care, Time to Hospitalization (Sample III, N=272)

Variable	Coefficient	S E	Coefficient/ S E	Odds Ratio (95% C I)
Age	0 013	0 009	1 458	1 01 (0 99 - 1 03)
Gender	-0.139	0 205	-0 677	0 87 (0 58 - 1 30)
PEC	-0 049	0 285	-0 175	0 95 (0 55 - 1 66)
Headneck	0 231	0 263	0 876	1 26 (0 75 - 2 11)
Chest	0 251	0 220	1 142	1 28 (0 83 - 1 98)
Abdomen	-0 079	0 238	-0 332	0 92 (0 58 - 1 47)
Multiple	0 058	0 271	0 215	1 06 (0 62 - 1 80)
ISS	1 922	0 309	6 211	6 84 (3 73 - 12 52)
MVA	0 395	0 227	1 732	1 48 (0 95 - 2 32)
Gunshot	0 988	0 379	2 608	2 69 (1 28 - 5 65)
ACS-Compatibility				
I vs II	0 052	0 344	0 152	1 05 (0 54-2 07)
I vs III	-0 390	0 305	-1 277	0 68 (0 37-1 23)
Time to Hospital				
> 60 min, vs ≤ 60 min	1 113	0 444	2 506	3 04 (1 28 - 7 27)

~~Goodness of Fit $\chi^2_{337} = 196\ 2$, p = 1.00~~

APPENDIX D

Assessment of Multicolinearity for Final Logistic Models

Table D 1. Correlation Matrix of Logistic Regression Coefficients

Variable	(r) Variable				
	Age	ISS	MVA	Time to Hospital	Gunshot Injury
Age	1 000				
ISS	0 073	1 000			
MVA	0 159	-0 064	1 000		
Time to Hospital	-0 134	0 368	0 003	1 000	
Gunshot Injury	0 157	0 119	0 328	0 090	1 000

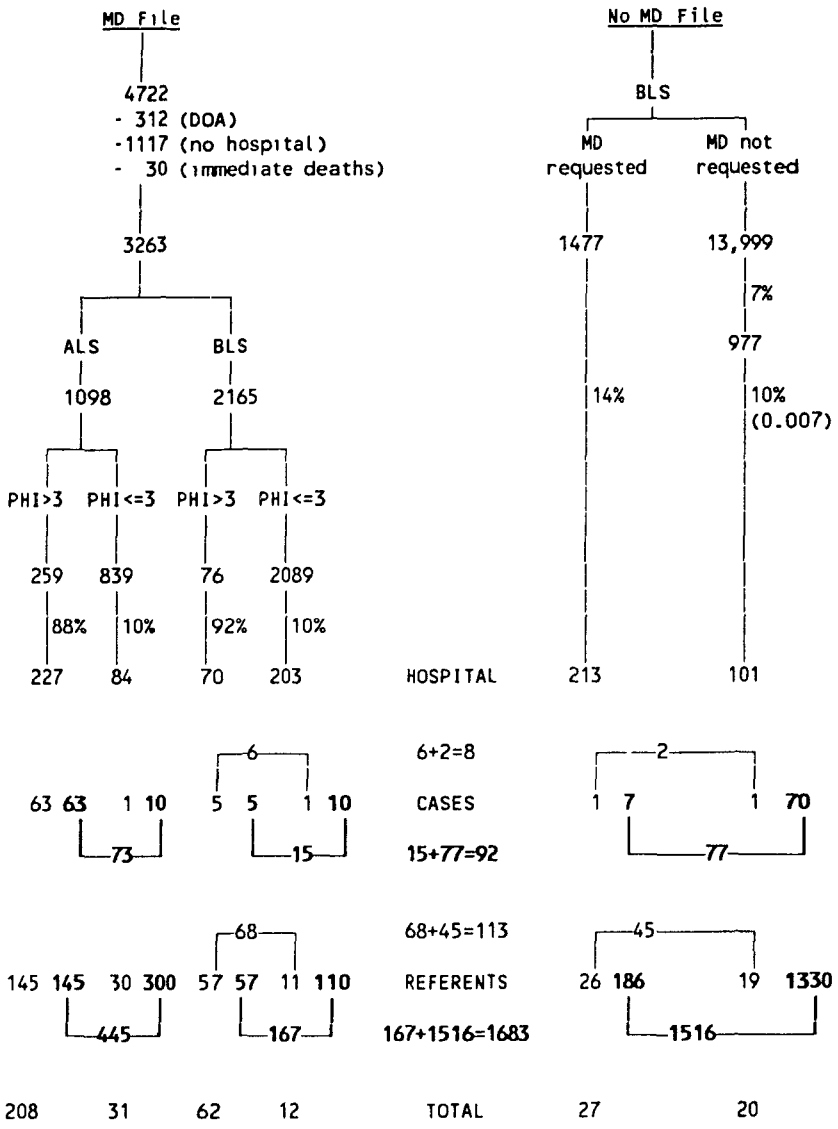
Table D 2 Correlation Matrix of Coefficients of Final Logistic Model

Variable	(r) Variable					
	Age	ISS	MVA	Time to Hospital	Gunshot Injury	ALS
Age	1 000					
ISS	0 045	1 000				
MVA	0 176	0 051	1 000			
Time to Hospital	-0 173	0 352	0 000	1 000		
Gunshot Injury	0 138	0 198	0 392	0 083	1 000	
ALS	-0 031	-0 235	-0 223	-0 064	-0 216	1 000
ACS-Compatibility of Hospital	-0 107	0 149	0 012	-0 029	0 128	0 165

APPENDIX E

Estimations of Sampling Fractions

Figure E.1 - Sampling Procedures



Bold-faced numbers represent estimates of total based on the sampling.

Table E.1. Estimation of Final Sampling Fractions

	ALS	BLS	
Cases	64 [73]	8 [92]	72 [165]
Referents	175 [445]	113 [1683]	288 [2128]

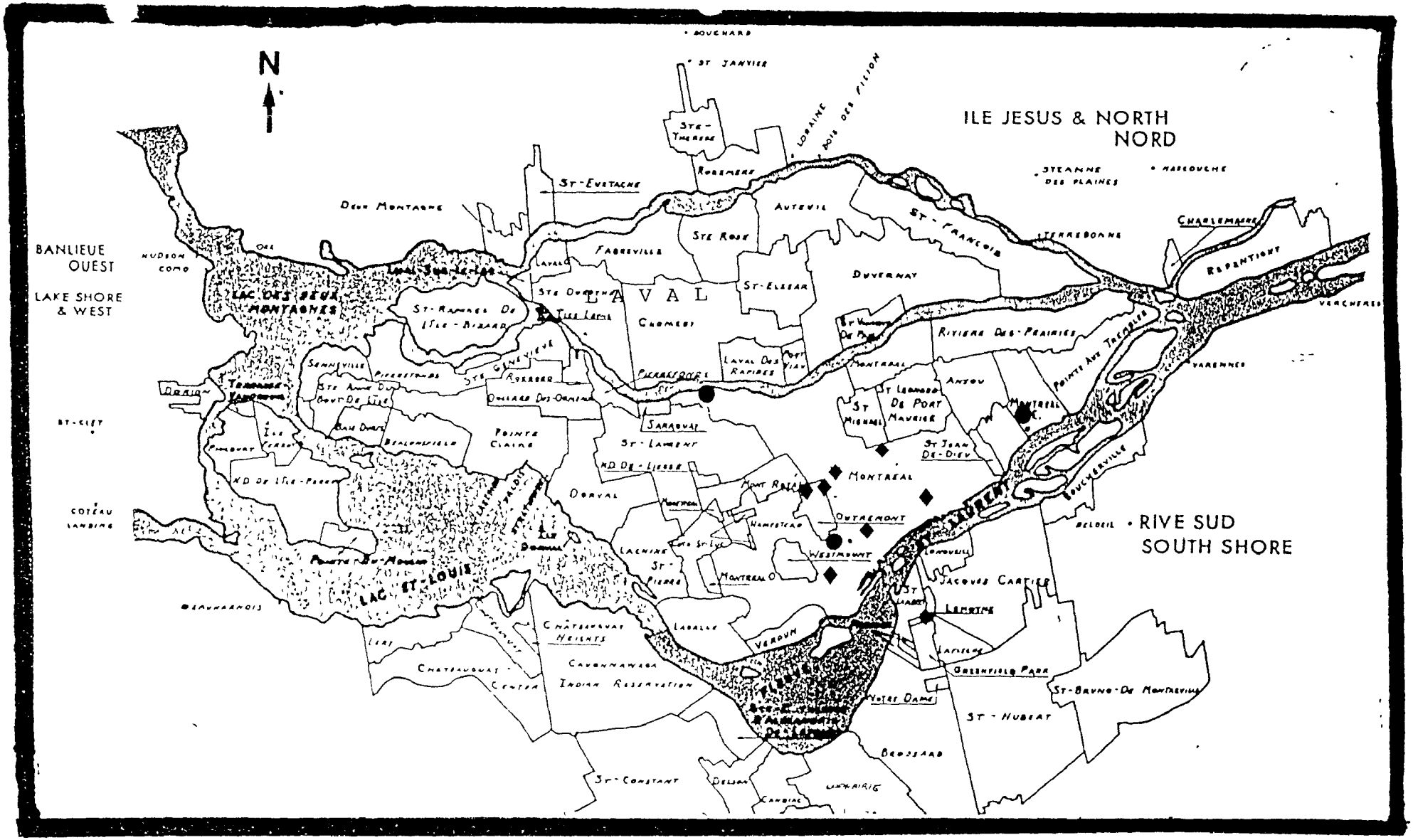
[Estimated Total]

fa = 64/73 = 0.876
fb = 8/92 = 0.087
fc = 175/445 = 0.393
fd = 113/1683 = 0.067

$$\frac{fa\ fb}{fb\ fc} = 1.755$$

APPENDIX F

Map of Montreal and Laval


N
ILE JESUS & NORTH
NORD
BANLIEUE
OUEST
LAKE SHORE
& WEST
LAVAL
MONTREAL
RIVE SUD
SOUTH SHORE
LAC DES DEUX MONTAGNES
LAC ST-LOUIS
ST-EUSTACHE
DEUX MONTAGNES
STE-ROSE
FABREVILLE
DUVERNAY
ST-FRANCOIS
CHOMEDEY
ST-VINCENT DE PAUL
RIVIERE DES-PRAIRIES
POINTE AUX TREMBLES
ST-LAURENT
ST-LAMBERT
DORVAL
LACHINE
LASALLE
VERDUN
OUTREMONT
WESTMOUNT
JACQUES CARTIER
LONGUEUIL
ST-BRUNO-DE MONTARVILLE
ST-NUBERT
ST-CONSTANT
CHATEAUGUAY
CHATEAUGUAY HEIGHTS
CAUGHNAWAGA INDIAN RESERVATION
ACS Level I Compatible Hospital
ACS Level II Compatible Hospital