Title

The contribution of the mechanism of injury, and the influence of age and alcohol ingestion in determining injury severity for patients who fall

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Publication Date

1989

The Contribution of the Mechanism of Injury, And the Influence of Age and Alcohol Ingestion in Determining Injury Severity For Patients Who Fall

by

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THESIS

Submitted in partial satisfaction of the requirements for the degree of

MASTER OF SCIENCE

in

Nursing

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA

San Francisco

[redacted]

Date University Librarian

Degree Conferred: . . SEP 03 1989 . . . .

Dedication

Several years ago, I never dreamed of completing a thesis, let alone achieving a Master of Science degree. Thanks to my parents, Michael and Mary Fazio, I have always strived for new goals. As I grew up, they instilled values of integrity, sensitivity, self-worth, and determination. Although neither parent has yet obtained an academic degree, their life experiences surpass much of what one may learn in school. With love, I dedicate this thesis to my parents.

Acknowledgments

I gratefully acknowledge the love and support I received from my partner, Michael Sanderson, during this endeaver. He reminded me that watching a movie together gave me a healthy frame of mind in which to write. He is truly the wind beneath my wings.

I also gratefully acknowledge the wisdom and support I received from members of my thesis committee. Susan Janson-Bjerklie, my chairperson, skillfully guided my discovery of advanced nursing practice and the research process. Mastering trauma nursing, Barbara Bires was able to talk trauma with me, which helped me identify and narrow my focus. Richard Cales helped me determine the appropriate independent variables as he shared his expertise in trauma and the research process. For this, I am grateful.

I appreciate the consultations I received from Steve Paul as he brought to light the power of statistics. I also give special thanks to Carol Shagoury. Not only did she compute the ISS for the sample, but she shared her clinical advice.

Abstract

The Contribution of Mechanism of Injury, and the Influence of Age, and Alcohol Ingestion in Determining Injury Severity for Patients who Fall

by

John R. Fazio

Falls are the most common cause of nonfatal injury and the second leading cause of unintentional injury-related deaths in the United States. A correlational research design was used to determine the individual and total percentage of the variance in injury severity that was explained by mechanism of injury of falls (height, landing surface, primary point of impact, whether the fall was broken, and intention), age, and alcohol ingestion. The retrospective sample included 215 patients who fell, were transported by the Emergency Medical Service system, and evaluated at a level one trauma center from July 1 to December 31, 1988. The Injury Severity Score (ISS) was used to measure the severity of injury. During the chart review, research variables were abstracted from the medical record to a data collection form. Autopsy reports were available. Patient characteristics were identified using descriptive statistics of frequency and means. A stepwise regression model was used to evaluate the degree to which the independent variables determined ISS. Results indicated that height explained 54%, landing surface explained 3%, and age explained an additional 2%, resulting in a total of 59% of the variance in injury severity explained. This finding can assist nurses in performing triage, directing clinical management, and predicting outcomes in patients who fall.

Author		Advisor

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CHAPTER I

The Study Problem

Introduction

Injury devastates victims and families with its abrupt impact, claiming 160,000 lives annually. One out of three Americans will be touched by injury sometime during their life, accounting for more than 25% of hospital emergency department visits. Injury is the major cause of death of persons aged one through 38. It is the third cause of death for persons of all ages. The cost in years lost of potential productive life exceeds that caused by cardiac disease and cancer combined. The annual direct and indirect costs have been estimated between 75 and 100 billion dollars (Baker, O'Neill, & Karpf, 1984; Committee on Trauma Research, Commission on Life Sciences, National Research Council, & Institute on Medicine, 1985).

Although injury is a major health problem, it has attracted little attention until recently. DeHaven (1952) defined the concept of mechanism of injury while describing injuries sustained after victims fell from great heights. The implications of these defining characteristics concerning falls are still generally unrecognized, despite this classic research (Baker et al., 1984). Knowledge of these epidemiologic determinants of falls should direct trauma nursing care from resuscitation through discharge. With a high index of suspicion of injuries, trauma nurses can perform precise assessments, institute timely life-saving interventions, and conduct comparative trauma research.

In order to study the epidemiology of falls, researchers have examined susceptible groups and the defining characteristics that influence injury severity. Preliminary examinations of selected groups revealed that substantial age differences existed between injured and uninjured persons. Injury rates were high among those under 45 years old, but the elderly had higher injury mortality (Committee on Trauma Research et al., 1985). Age was the most consistent research variable identifying differences in fall rates, with an increased incidence in early childhood and older adulthood (Garrettson & Gallagher, 1985). It is not known how these differences correlate with the mechanism of injury of falls. Also, the ingestion of alcohol influenced the likelihood of all types of injuries (Committee on Trauma Research et al., 1985). Most relevant research has examined motor vehicle accidents and intoxicated driving, but has failed to address vertical deceleration during falls. For the mechanism of injury of falls, the velocity at impact during the fall determines the extent of mechanical energy dissipated. This velocity is determined by the height of the fall and whether the fall was broken (Baker et al., 1984). Death usually occurs after a fall of six stories or greater (Kazarian, Bole, & Ketchum, 1976), however, there is evidence of survival of falls from greater heights. The American College of

Surgeons (1986) has proposed that a fall of 20 feet or greater may produce significant injury (see Appendix A). Injury is also related to the stopping distance, but little is known about the effectiveness of the energy absorbing properties of the landing surface or body point of impact. The exhaustive research which describes the environmental characteristics and impact surfaces with vehicular injuries is lacking in research describing fall injuries.

Statement of the Problem

The relationship between selected defining characteristics (height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention) of the mechanism of injury of falls and injury severity is not known. Also, the impact of age and alcohol ingestion on victims that have fallen has not been adequately demonstrated.

Purpose of the Study

This study has the following specific aims: (a) determine the individual and total percentage of the variance in injury severity that is explained by selected defining characteristics of the mechanism of injury of falls, and (b) after mechanism of injury is accounted for, determine the influence of age and alcohol ingestion in further explaining the variance in injury severity.

Significance of the Study

Falls are the most common cause of non-fatal injury and the second leading cause of unintentional injury-related deaths in the United States, being surpassed only by motor vehicle accidents (Baker et al., 1984; Committee on Trauma Research et al., 1985). Annually, 13,000 fall-related deaths are reported (Baker et al., 1984). This may be an underestimation since falls are underreported as a cause of death on death certificates (Lambert & Sattin, 1987). Significantly, falls are the second leading cause of spinal cord and brain injury (Baker et al., 1984). Outcome results put heavy demands on the health care system, and involve unnecessary suffering and inconvenience for the patient and family.

Resulting from concern over the number of deaths and injuries due to falls, a measurable objective of no more than two deaths per 100,000 persons by the year 1990 was established (United States Department of Health and Human Services, 1980). Experts estimated the death rate from falls will actually be 4.2 per 100,000 persons in 1990 (Lambert & Sattin, 1987). The projected goal will not be met, therefore, more research is indicated. Epidemiologic data revealed that progress has been made. The number of deaths from falls declined from 1978 to 1984 (Lambert & Sattin, 1987). A more thorough examination revealed that the declining death rate was not uniform among all ages. There was little change for the ages 15 to 24. In 1984, the death rate for persons aged 65 to 84 increased. This impacts the future since the elderly are increasing in number and proportion (Rice, 1985).

It has been recommended to collect refined data on specific types and causes of injuries and exposures to injurious environments (Committee on Trauma Research et al., 1985; Waller, 1985). Identifying those at risk, types of injuries sustained, severity of injury, and mechanism of injury will identify strategies for change, resulting in reduced morbidity and mortality of severely injured victims. The goal is to have the right patient receive the right care at the right time (Trunkey, Siegal, & Baker, 1983).

Assumption of the Study

All injured patients evaluated at the trauma center located in the City and County of San Francisco received acceptable standards of care from resuscitation through discharge or death.

Research Questions

The research questions were as follows: (a) What is the individual and total percentage of the variance in injury severity that is explained by mechanism of injury of falls (height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention)? and (b) What is the degree to which age and alcohol ingestion further explain the variance in injury severity after mechanism of injury variables are accounted for?

Definition of Terms

Acute Alcohol Ingestion

Acute alcohol ingestion is the recent intake of an alcoholic beverage that results in a subjective interpretation of alcohol on the breath, or an estimated plasma alcohol level of 100 mg/dl or greater on initial presentation.

Base Station

Base station is a hospital that provides quality assurance and on-line medical control for the EMT-P and MICN.

Base Station Hospital Record

Base station hospital record is a one page form that documents the prehospital communication between the MICN and EMT-P for patients transported by the EMS system (see Appendix B).

Blunt Loading

Blunt loading is the dissipation of mechanical energy by a disc instrument.

Chronic Alcohol Ingestion

Chronic alcohol ingestion is the excessive intake of alcoholic beverages over time that is acknowledged by the patient.

Emergency Medical Service (EMS)

Emergency Medical Service is an organized approach to deliver acutely ill and injured patients to a location for definitive care.

Emergency Medical Technician-Paramedic (EMT-P)

Emergency Medical Technician-Paramedic is a certified technician with limited formal emergency training that initiates care for patients in the prehospital period and transports them for definitive care.

Fall

Fall is the act of dropping from a higher to a lower place, not resulting from an acute medical event.

Height of the Fall

Height of the fall is the vertical distance from the starting level to a given point.

Injury

Injury is a consequence that occurs after the dissipation of energy whereby the tissues are deformed beyond their recoverable limits.

Injury Severity Score (ISS)

Injury Severity Score is an anatomic index which rates and compares severity of injuries by characterizing the amount of anatomic damage sustained.

Intention

Intention is the action by self or others that results in a purposeful fall.

Landing Surface

Landing surface is the type of material impacted.

Mechanism of Injury

Mechanism of injury is a classification based on injury circumstances that is related to the type of injurying force and subsequent tissue response.

MICN Log

MICN log is a written record of the date of occurrence, name, and mechanism of injury for patients transported by the EMS to the trauma center.

Mobile Intensive Care Nurse (MICN)

Mobile Intensive Care Nurse is a certified nurse with advanced training in the care of the patient during the prehospital period that directs care during this time through radio communication with the EMT-P.

Prehospital period

Prehospital period is the time from the onset of the injurying force to the arrival at the trauma center.

Primary Point of Impact

Primary point of impact is the first part of the body that strikes the landing surface during a fall.

Terminal Velocity

Terminal velocity is the maximum velocity which a falling body will attain in a free fall.

Trauma

Trauma is a term used to describe a variety of injuries. It is used synonymously with injury or accident.

Trauma Center

Trauma center is a hospital that has the ability to provide immediate, optimal care to the injured patient.

Trauma Nurse

Trauma nurse is a nurse with specialized training in the proficient care of the injured patient.

Trauma Nurse Clinician

Trauma Nurse Clinician is a trauma nurse with knowledge and skills necessary to calculate the ISS.

Whether the Fall was Broken

Whether the fall was broken is the act of increasing the stopping distance during a fall which may lessen the injury severity.

CHAPTER II

Review of Relevant Literature

Introduction

This chapter includes a review of the relevant literature as it relates to the study problem. It begins with a discussion of the conceptual framework underlying the study. The following research variables are included: height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention. Current research is reviewed in sections on mechanism of injury of falls, age, alcohol ingestion, and injury severity.

Conceptual Framework

Injury Occurrence

Haddon and Baker (1981) developed a model to explain injury occurrence. This model describes injury as an event that occurs by the interaction among human factors, energy sources, and the physical and social environments. Human factors include: age, gender, fatigue, and alcohol ingestion. Energy sources can be mechanical, thermal, radiant, chemical, or electrical. Most injuries after falls are caused by mechanical energy, whereby kinetic energy is transferred to the body to cause injury. The dissipation of this energy is related to the height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention (DeHaven, 1952; Baker et al., 1984). Environmental factors include knowledge level, social attitudes, and variables within the physical environment. Variables within the environment may determine whether the fall was broken and the landing surface. Knowledge of the interaction among these injury concepts may predict the extent of injury severity (Haddon & Baker, 1981).

Height of the Fall and Whether Broken

Velocity is determined by the height of a fall. Although velocity is independent of mass, it is modified by air drag, humidity, and position of the falling body (Snyder, 1963). These factors alter the time of deceleration as the fall may be broken. If the fall is broken, the velocity will be decreased and injury lessened.

Laws of Physics and Biomechanics may be used to predict the forces and the resultant injury after victims fall (Robertson, 1983). Transferred kinetic energy is a function of mass and velocity ($KE = mv^2 / 2$). The mass is calculated after dividing the weight by a constant 32. The velocity is the distance an object moves in some unit of time. Foot pounds, the unit of measurement for kinetic energy, is the energy necessary to lift a given number of pounds one foot at the earth's surface. If the height is known, then the distance traveled is known. Acceleration from gravity, the rate of increase in speed of a free falling object, is constant at 32 feet/second. It has been determined that after falling about 482 feet, a body reaches a terminal velocity of 120 miles per hour (Snyder, 1963). The following equation relates acceleration to the distance and velocity: $v_t^2 = v_0^2 + 2ad$. This equation may be used to calculate the tolerance to mechanical energy and absorption of energy in a free-fall (see Appendix C). A person who falls from a scaffold 60 feet from the ground begins with zero velocity. The final velocity squared is 3,840 feet/second. The speed at impact is the square root of 3,840, or 62 feet per second. If the person weighs 150 pounds, then the kinetic energy at impact is 9,005 foot pounds.

Landing Surface

Injury severity after a fall is determined by characterictics of the environment, including landing surface and what is beneath it (DeHaven, 1942; Haddon, Suchman, & Klein, 1964; Haddon, 1980). The relative elasticity or solidity of material impacted determines the resultant injury from the duration of impact. Sudden impact, common with falls, causes damage to the structural integrity of tissues. However, injuries are distributed in severity throughout the range of material impacted (Baker et al., 1984).

Primary Point of Impact

The nature and extent of injuries correspond with the position of the body at impact. Feet first impact, the most common, is related to injuries of the lower extremities. Head and chest injuries are more common with head first impact. Most of the impact during a fall is absorbed by the rigid skeleton, explaining the high incidence of skeletal injuries.

Intention

Ciccone and Richman (1948) found that landing stiff-legged produced more fractures of the heel. A voluntary bending with impact may decrease injury. This relates to intention since victims of intentional falls may be more physically relaxed.

Literature Review

Mechanism of Injury of Falls

A few studies have correlated height and severity of injury. Only one study defined injury severity using the ISS. This prospective study described the injury and outcome of 73 adult patients admitted to an urban hospital after intentional falls (Bostman, 1987). The author did not discuss how he determined and verified intention. Also, the intention of those that died after falls may have been unknown. Scatter plots showed a positive correlation between height and ISS. There was adequate range of falls between two to six stories. Outcome was also measured by the social recovery one year after the fall. Although 32% returned to work, a significant number (48%) were physically disabled after the fall. Since some had pre-existing mental illness, this figure may be misleading. Although the researcher measured acute alcohol ingestion with an expired air alcohol detector, he did not discuss alcohol's effect on injury or outcome.

Scalea et al. (1986) reviewed 161 adult patients, admitted over 36 months, who jumped or fell from a height of one to seven stories and survived emergency department resuscitation. Those that fell five or more stories had a mean ISS of 41. There were no deaths from heights less than or equal to three stories. Sixty percent of the patients presented in shock, yet more than two thirds had angiographically demonstrated retroperitoneal hemorrhage. They concluded patients in shock after falls were more likely to be bleeding from retroperitoneal than intraperitoneal sources. The authors failed to include those who died or those not taken to their trauma center. This may represent selection bias. Fractures were the most common injury sustained. All but one of the patients that fell four or more stories sustained major fractures. Percentages were used to demonstrate a correlation between height and presence of fractures, and height and severity of fractures. Results must be interpreted cautiously, since there were small numbers of patients that fell five or more stories. The influence of age was not examined.

Without determining ISS, a questionnaire was answered by 1,431 college seniors which investigated the frequency and severity of injury concerning falls from beds (Dedrick, Burney, Hensinger, & Mackenzie, 1988). Only 7% actually fell a mean distance of 136 centimeters. The authors found the rate of injury corresponded to the distance fallen. For falls 61 to 122 centimeters, 45% reported injury. If greater than 122 centimeters, 95% reported injury. There were no injuries from standard beds. Injury was more likely to occur from a bunk bed or loft ($p = .025$).

Examining the impact of height, a retrospective chart review of 200 patients that fell and were admitted to a New York city hospital was conducted (Reynolds, Balsano, & Reynolds, 1971). Histograms were used to display that as the height of the fall increased, the mortality increased. Death was more frequent in the age zero to ten group (32%) and 51 and over group (64%). Head injury was associated with higher mortality (68%). The number of skeletal injuries did not increase with increased mortality, however, skeletal injuries associated with pelvic, cranial, and visceral organ injuries resulted in death (100%). Of the 324 skeletal injuries, the order of frequency was: lower extremity, upper extremity, skull/facial bones, vertebrae, and pelvis. The os calcis fracture associated with a vertebral fracture was less common than expected (19%).

Lewis, Lee, and Grantham (1965) identified a jumper's syndrome while descibing 53 victims of three or more story falls to pavement. Pavement has a short duration of impact. Twenty-one survived, with the highest fall with survival from eight stories. Deaths were due to brain and thoracic injury, and intra-abdominal hemorrhage. Falls were defined as low and high since patterns of injury varied. Low falls resulted in fracture of os calcis and vertebrae as victims impacted their feet. This pattern was absent with high falls due to the variety of body positions at impact. Once again, height of the fall may affect body position which determines injury severity.

For 43 victims that fell ten feet or greater, velocity at impact was shown to have no relationship with skull fractures (Cummins & Potter, 1970). Frontal scalp injuries were the most common (37%). The authors concluded that head injury can be decreased if the victims protected themselves with their limbs. Infants less than five years old sustained twice as many skull fractures as adults, but had less brain injury. The infant skull is less rigid and can absorb the force of impact. The average height of fall with serious brain injury was 16 feet. The site of impact also determines the force and injury severity. The three fatal cases in this study all impacted concrete.

Mechanism of injury research using animal models has examined abdominal injury. Specifically, height of the fall was examined. Dissipation of mechanical energy from a fall was simulated with blunt loading to the abdomen. Knowing the speed of blunt loading to the abdomen is important since the viscera can deform without injury if the force is applied slowly (Penberthy, 1952). Biomechanics of injury research on rabbit models supported the concept that increased velocity of impact increased the severity of injury (Lau & Viano, 1981b). This is related to the height of a fall. Lau and Viano (1981a) have demonstrated that cardiovascular and liver injury severity increased with impact velocity. The risk of sustaining an abdominal injury is a function of impact velocity times forced abdominal compression (Rouhana, Lau, & Ridella, 1985). This relates to height of a fall and primary point of impact. The researchers found a difference in left and right side tolerance to injury (Rouhana et al., 1985). Hepatic injury was associated with right side impact. Left side impact caused less splenic injury than expected. Renal injury was associated with left and right side impact. Results from the biomechanics research must be critiqued cautiously since they were conducted on rabbit models. Blunt loading was applied by a disc instrument, and not resulting from falls.

Some studies have demonstrated no relationship between height and injury severity. Researchers examined injuries in 66 children sustained in free-falls (Smith, Burrington, & Woolf, 1975). Subjects were included whether they were admitted or not. Fifty percent of the falls were from 12 feet or less. Upper extremity, skull, and femoral fractures were the most common injuries. A total of 70% of the skull fractures were associated with falls 36 feet or higher. There was an increased frequency of head injuries, with only one os calcis fracture. A histogram displayed that there was no correlation between age and height of falls. Using scatter plots, the authors found no correlation between radius or femur fractures and height.

The authors failed to explain how age, height, and injuries were measured reliably. Generalization is questionable due to the small sample and selection bias of children from urban areas who are likely to fall from greater heights.

A more recent study by Lowenstein, Yaron, Carrero, Devereux, and Jacobs (1989) reported the patterns of injury for 12 victims who fell or jumped from great heights and landed on their feet to hard surfaces. The distance ranged from 20 to 100 feet. Eleven of the 12 survived. They sustained 49 significant injuries, with skeletal injuries the most frequent. Craniofacial trauma and fractured hands and wrists were observed as a result of secondary impact. Despite the small sample size, 48 of 49 injuries were identified in the emergency department within the first hours of care. The researchers found no correlation between height of the fall and number of injuries ($r = .35$, $p = .25$) or hospital length of stay ($r = -.27$, $p = .39$). They failed to correlate other factors that affect outcome including: landing surface, primary point of impact, and duration of impact. Injury severity was not defined using the ISS.

Case studies have been used to not only diminish the impact of height, but to emphasize the importance of the landing surface. Kazarian, Bole, Ketchum, and Mersheimer (1976) detailed the circumstances of a 17-year-old male who survived a 17 story free-fall. The victim landed on a steel fence, bushes, and mud. Variables affecting outcome, previously summarized by Snyder (1963), were discussed as follows: orientation of the body, distribution of force, magnitude of force, material impacted, and time duration at impact. The survival implied that tolerance is not always related to the distance fallen. The authors concluded the material impacted was the most important factor determining survival. They failed to use inferential statistics to support their conclusions.

Layton, Villella, and Kelly (1981) also used a case study of a 24-year-old male survivor of a free-fall to discuss variables affecting injury severity. Variables included: body position, distribution of force, magnitude of force, nature of material impacted, and duration of impact. The victim fell 17 stories and landed supine on the trunk of an automobile. He sustained a C6 non-displaced fracture, T3 compression fracture, left scapular fracture, and bilateral forearm fractures. Despite a fall from a great height, the larger distribution of force and longer duration of impact to the unique landing surface resulted in decreased injury severity.

Since the landing surface seemed to affect injury severity, Snyder (1966) used case histories to discuss survivals of free-falls into the snow. Snow has contributed to impact survival, with the resistance of snow varying with density, temperature, and grain structure. For 22 impacts with snow resulting in injury or death, no injury was noted to occur under 40 feet. Snow increased the duration of the impact and may be protective up to a height of 40 feet. The researcher failed to discuss those who fell into the snow and died.

Seymour, Phillips, and Mann (1987) discussed the case of a 20-year-old intoxicated female who intentionally fell 12 stories. Again, landing surface was emphasized. The victim landed on concrete which was covered with some plastic garbage bags and a thin layer of snow. She survived with the following injuries: pneumothorax, right seventh rib fracture, liver laceration, retroperitoneal hematoma, L5 transverse process fracture, pelvic fracture, bilateral ankle fractures, and bilateral os calcis fractures. Despite the fall from a great height onto concrete, the impact was lessened from the garbage bags and snow, which is an excellent impact absorbing surface. Normally, concrete has a maximum deflection of 1/1000 centimeter which makes it the worst surface to impact. The alcohol ingestion may have decreased the muscle tone, contributing to the victim's survival.

Following investigations at the site of falls for 137 victims, Snyder (1963) documented data associated with survival of extreme impact forces after falls up to 275 feet. Graphs displayed that there was no correlation of impact velocity and injury. The investigator was able to identify factors which determined injury. He found that body position directly influenced the nature and extent of injuries. Those victims with feet first impact had more structural trauma to the lower extremities, producing fractures to the calcaneus, distal fibula and tibia, mid-shaft femur, and lumbar vertebrae. Head impact resulted in a higher incidence of head, shoulder, and thoracic injuries. Distribution of force also determined injury severity. The greater the area over which the force is applied, the smaller the force per unit area. For those landing feet first, the degree of voluntary bending of the knee during impact influenced injury severity. Landing stiff-legged resulted in fractured heels and those physically relaxed suffered less injury. Those victims with alcohol intoxication had a disproportionate survival rate which may be due to alcohol's effect on the neuromuscular system. The muscle relaxation after alcohol ingestion may reduce injury. Cautious interpretation is indicated since the study's subjective determination of alcohol ingestion has questionable reliability. The magnitude of force during impact was shown to be dependent on the distance fallen and the duration the force is applied. If impact lasts less than 0.2 seconds, tissues react with damage to structural integrity. This is related to the material impacted since the relative consistency of the impacted surface directly affects the deformation distance and thus duration of impact. Concrete has a non-yielding characteristic, whereas wood often deforms considerably prior to breaking in impact.

Some studies have emphasized the relationship of injury severity and whether the fall was broken, primary point of impact, and intention. DeHaven (1942) examined seven victims that survived a free-fall of 50 to 150 feet. Injuries included: one skull fracture, three rib fractures, one fractured humerus, two vertebral injuries, and one fractured pelvis. Only one patient died 24 hours after injury. Two common factors of survivors were a transverse application of the decelerative force, and a longer distance through which they decelerated. The height of the fall was less significant in determining survival compared to the surface area and that the fall was broken. The small sample size failed to include non-survivors.

Eighty-six percent of fractures sustained while parachuting were isolated to the lower extremeties (Ciccone & Richman, 1948). Most injuries involved weight bearing structures as the forces were transferred to the long bones and vertebral column. This mechanism of injury resembled falls with vertical impact and was related to the primary point of impact, whether the fall was broken, and intention.

Maull, Whitley, and Cardea (1981) described injuries for six victims that sustained vertical deceleration injuries after an elevator fell three stories to the ground. More severe injury occurred with vertical axis application of decelerative forces. Injuries involved weight bearing structures as the forces were transmitted through the foot, leg, pelvis, and vertebral column. They concluded the severity of injury increased by increasing the rate of deceleration, and decreasing the distance the body was decelerated. This emphasizes the influence of the height of a fall, primary point of impact, and whether the fall is broken. Comprehensive mechanism of injury information was difficult to obtain with this retrospective study.

New York City was identified as having a unique problem with falls from high rise apartments, not single story dwellings, resulting in free-falls from greater distances (Sieben, Leavitt, & French, 1971). For 55 children, 139 injuries occurred after falls consisting of: cerebral concussion (20%), skin lacerations (32%), visceral injuries (13%), and cranial vault fracture (12%). Visceral injuries and fractures were uncommon in falls less than three stories (7%). Characteristics of those that died (9%) included: age greater than one and less than four years, fall from window, multiple extensive skull fractures and bilateral cerebral lacerations, and hepatic contusion. Three of the 48 survivors with no major injuries fell five stories. One victim bounced from a second story awning to the pavement, while another landed on a clothesline prior to impact. The falls were broken despite impact to a hard surface resulting in less injury severity. The third victim fell into a pile of garbage, which was a softer surface impacted.

Finally, a few retrospective studies of humans that sustained injuries from impact falls with water have been conducted. Autopsy results revealed a significant incidence of pneumothorax, hemothorax, and pulmonary contusion (Snyder & Snow, 1967; Robertson, Lakshminayans, & Hudson, 1978; Lukas, Hutton, Lim, & Mathewson, 1981). Entering feet first resulted in less severe injuries. The position and orientation of the body at the time of impact was important (Lukas et al, 1981). Once again, the primary point of impact determined injury severity. The condition of the water current and effects of drowning were not discussed for this unique landing surface.

Age of the victim

The mortality rate from injury is much higher in the elderly (Lauer, 1959; Oreskovich, Howard, & Copass, 1984; Nygren, 1984; and National Safety Council, 1985). For a high ISS result (50 or higher), there was no difference in mortality, but for lower scores (ten to 19), the death rate for age 70 and over was greater than eight times the rate for persons less than 50 years old (Baker, O'Neill, Haddon, & Long, 1974). More recently, Oreskovich et al. (1984) found that deaths in injured patients aged 70 or older was five times greater than younger patients. The increased mortality in the aged was most pronounced when injuries were least severe.

The concept of LD-50 has been added to injury severity determination. This is the severity of injury that is a lethal dose for 50% of patients injured. Bull (1982) found an age dependent relationship for LD-50: ISS 40 for age 15-44, ISS 29 for age 45-64, and ISS 20 for age 65 or older. Less injury severity was required to have a significant effect on mortality of the elderly since a given impact resulted in a greater magnitude of injury (Baker et al., 1974, Baker & O'Neill, 1976; West, 1981). Suggested reasons for increased mortality are: difficulty in diagnosis, limited organ reserve, anatomic changes, and concurrent medical diseases (Herron, Jesseph, & Harkins, 1960).

As people age, they have high rates of falls and fall injuries (Gryfe, Amies, & Ashley, 1977). The elderly frequently have impaired vision, gait, and balance. Their risk of death from falls also increases (Lambert & Sattin, 1987). Thirty percent of all deaths from falls occur at age 85 or older, while 50% occur at age 75 or older (Baker et al., 1984). Baker et al. (1984) reported that a fractured hip as a result of falls was especially influenced by age. Osteoporosis results in fragility of bones and loss of bone mass in the elderly. This may produce the age associated increase in fracture rates. Hospitalization rate for all fractures, excluding the hip, was three times as high for those age 85 and older as for age 65 to 74. Advanced age substantially increases the likelihood of hospital admission after minor fractures (Baker et al., 1984). Age contributes to extent of injury and death, and may help determine injury severity.

Alcohol Ingestion

Ingestion of alcohol is the most frequent variable associated with injury (Committee on Trauma Research et al., 1985). Acute ingestion is known to affect judgment and increase risk taking behavior which increases the risk of falling (Bowden, Wilson, & Turner, 1958; Cohen, Dearnaley, & Hansel, 1958; Honkaren et al., 1983; Strang, McMillan, & Jennett, 1978). Injuries occur due to the altered cognitive ability and motor coordination. Research has shown that there was significant swaying with a blood alcohol level over 100 mg/dl (Perrine, 1973). There was also divided attention span and reduced visual acuity. Many subjects were affected at much lower blood alcohol levels.

Alcoholics have increased death rates from accidental falls, motor vehicle accidents, and other accidents (Brenner, 1967; Schmidt & De Lint, 1972; Nicholls, Edwards, & Kyle, 1974). They are 16 times more likely to die as a result of falls (Brenner, 1967). This may be related to the acute or chronic effects of alcohol ingestion. Both acute and chronic ingestion has been shown to have adverse effects on the immune system which impacts morbidity and mortality (Smith & Palmer, 1976). The vasodilation caused by alcohol ingestion results in hypotension (Swan, Vidaver, Lavigne, & Brown, 1977). This may impair efforts during the resuscitation following a fall.

Some researchers have suggested that acute alcohol ingestion may lessen injury severity. The catecholamine secretion associated with alcohol ingestion may have a protective effect. Studies examining vehicular injury have demonstrated that the severity of injury was unaffected by alcohol ingestion (Ward, Flynn, Miller, & Blaisdell, 1982; Waller et al., 1986). The increased mortality found in other studies may have been due to a delayed treatment or socioeconomic disadvantage at accessing care. A history of chronic alcohol ingestion did not confirm that those dying were intoxicated at the time of the fall. All of these studies on alcohol ingestion failed to examine specific mechanisms or report causes or types of injuries.

Injury Severity

In 1971, attempts were made to quantify and determine injury severity. The American Medical Association Committee on Medical Aspects of Automotive Safety (1971) developed the Abbreviated Injury Scale (AIS) to rate tissue damage severity at patient discharge or death. Values in AIS were originally developed on the basis of clinical judgment. Scores are now obtained by consulting the AIS dictionary, which has subsequently been updated (American Association for Automotive Medicine, 1976, 1980, 1985). The AIS describes seven body regions with more than 1,200 entries: External, Head, Neck, Thorax, Abdomen/Pelvic contents, Spine, and Extremities. Each region is categorized as minor, moderate, serious, severe, critical or unsurvivable. Improvements of the AIS 1985 include: (a) inclusion of clinical terminology to describe thoracic, abdominal, and vascular injuries for more users, (b) links clinical and vernacular language, (c) provides more definitive methodology in injury assessment, and (d) incorporates penetrating injury into the AIS rating (American Association for Automotive Medicine, 1985).

Needing a rating tool for patients with multiple injuries, Baker et al. (1974) devised the ISS while examining 2,128 victims of vehicular trauma. The ISS is based on a quadratic manipulation of the AIS. Scores from the three most severely injured body regions from the AIS are squared and totaled to give a single overall score. For the ISS, including the forth or fifth most severely injured regions produced no significant increase in correlation between injury severity and mortality (Greenspan, McLellan, & Greig, 1985). The range of the ISS is zero to 75, but only 44 values are possibly obtainable. Since an increase in ISS value reflects an increase in injury severity, the ISS has become the most widely used single method for determining injury severity of the hospitalized patient (Cayton & Evans, 1979; American Association of Automotive Medicine, 1980; MacKenzie, 1984; Cales, 1986).

CHAPTER III

Methodology

Method

Introduction

The purpose of this study was to determine the percentage of the variance in injury severity that was explained by the mechanism of injury of falls, age, and alcohol ingestion. The variance in injury severity was measured by a stepwise regression model. Methodology issues are described in sections on design, setting, sample selection, instrumentation, validity and reliability of variables, and procedure.

Design

A correlational research design was used to discover the contributions of the defining characteristics of the mechanism of injury of falls (height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention), and the influence of age and alcohol ingestion in determining injury severity. The medical records from a sample of injured patients who fell were examined by the investigator after hospital discharge or death using a retrospective chart review.

Setting

This study was conducted for injured patients who fell in San Francisco, an urban city located in the Northern California. Data were collected at the only base station and trauma center for the City and County of San

Francisco. Prehospital protocols have been established and revised by the City and County of San Francisco, Department of Public Health, EMS Agency. Paramedic units were guided by the communication system at the base station, which provided medical control. According to pre-set criteria, patients who fell 15 feet or greater were transported to the trauma center. Patients who fell less than 15 feet were transported to the hospital of their choice. Average transport times were eight minutes or less (S. Campbell, personal communication, November 10, 1988).

Sample Selection

The subjects consisted of all patients who fell and were transported by the EMS and evaluated in the emergency department from July 1, 1988 through December 31, 1988. Those patients identified in the medical record who fell were retrospectively selected. Subjects were excluded from the study when: the patient signed out against medical advice or an acute medical event resulted in a fall.

To prevent loss of patient privacy, the research investigator handled all research records confidentially. Only the research investigator and Trauma Nurse Clinician had access to them. No individual identities were used in any reports or publications resulting from this research.

Instrumentation

Data collection form. The two page data collection form was developed by the researcher to record research variables for data analysis (See Appendix D). Face validity was assured on the simplicity of the format. The form was used to abstract research variables from the entire medical record during the retrospective chart review. As variables were identified, they were tallied on the data collection form. A worksheet was used to note information necessary to calculate the plasma osmolality and ISS (see Appendix E). All mathematical computations were completed using a calculator.

Injury Severity Score. The AIS and ISS were calculated by the Trauma Nurse Clinician at the trauma center after patient discharge or death from the standard criteria and formula (Baker et al., 1974). She is employed by the trauma center to calculate the AIS and ISS values for admitted trauma patients. Her results are used to plan trauma care and research. Inter-rater reliability with an expert in injury severity scoring was established by examining a random selection of 10% of the sample (r = .99, p = .00). Intrarater reliability for this study was established by comparing 25 randomly selected ISS results at two points in time (r = .94, p = .00).

Validity and reliability of variables

Injury Severity Score. An injury severity index should have high and known correlation with morbidity and mortality so it can predict outcome. Gibson (1981) displayed the concept that mortality increased disproportionately with the AIS rating of the most severe injury, accounting for 25% of the variance in mortality

(AIS 1 = 0%, AIS 2 = 0.5%, AIS 3 = 3%, AIS 4 = 16%, AIS 5 = 64%).

Bull (1982) computed the ISS for 1,333 victims of vehicular trauma and related the score to mortality, time to death, hospital length of stay, and disability. The ISS has correlated well with mortality (Bull, 1982), explaining 49% of the variance in mortality (Baker et al., 1974).

Through plotted curves, rather than reported correlation coefficients, Semmlow and Cone (1976) described their data on 8,850 patients from rural and urban areas. They concluded the ISS had a positive correlation with mortality, hospital length of stay, and likelihood of surgery.

In a retrospective study, Moylan, Detmer, Rose, and Schulz (1976) selected 823 (18%) major trauma patients from a total of 4,566 injured patients admitted to five Wisconsin hospitals. Major trauma was defined by the following inclusion criteria: head, chest, abdominal, or associated extremity injuries. One half of the injuries resulted from vehicular mechanisms. A panel of surgeons reviewed a sample of 237 medical records for quality of care. Quality of care was unacceptable for 16% of the sample. Histograms displayed that hospital length of stay was ineffective in evaluating care and assessing quality review. Results indicated that ISS was sensitive in identifying patients at greater risk for poor care. The authors concluded that attention should be focused on cases with an ISS in excess of 30.

To determine the relationship among variables, Stoner, Barton, Little, and Yates (1977) measured plasma cortisol levels and calculated ISS values from two groups of patients (174 fatal accidents, 189 mixed accidents). The plasma cortisol concentration is a sensitive measure of injury severity. All plasma cortisol concentrations were higher than those seen in normal circadian fluctuations. Contrasting those with ISS of four and ISS of nine, cortisol concentrations were higher in patients with ISS of nine ($p < .005$). There was no difference in samples taken within eight hours or up to 31 hours after injury. This confirms there was a difference in severity of injuries measured by the ISS.

An index must also have ratings with clear and objective decision rules for deriving and summing scores, so the same rater over time or different raters at the same time will have the same score for the same patient. This defines inter-rater and intrarater reliability.

Following a five hour training workshop, each of fifteen raters with varying qualifications (physicians, registered nurses, emergency medical technicians, and non-clinical technicians) coded AIS injuries sustained by 375 patients admitted to four urban hospitals (MacKenzie, Shapiro, & Eastham, 1985). Inter-rater and intrarater agreement of the AIS scores were measured using weighted kappa statistics with 95% confidence intervals. The authors used guidelines proposed by Landis and Koch (1977) to judge the relative degree of strength associated with kappa statistics. AIS scores were compared with the modal AIS and physician 1. Physician 1 ratings were the most accurate. There was substantial agreement with modal AIS (kappa range .66-.81). Agreement with physician 1 was moderate to substantial (kappa range .53-.74). The researchers acknowledged the kappa statistics were biased estimates of inter-rater reliability since they were calculated for multiple injuries sustained by the 375 patients. Inter-rater agreement of AIS scores was significantly higher for blunt vehicular (kappa range .84-.89) and blunt non-vehicular (kappa range .86-.89) versus penetrating (kappa range .80-.82) injuries. Intraclass coefficient was used to measure agreement among ISS results based on independent observations. For ISS, results indicated that as a group, physicians (.83) and nurses (.80) were more reliable than emergency medical technicians (.76) or non-clinical technicians (.66). Intrarater agreement was examined by comparing AIS scores at two different points in time. The agreement was substantial to almost perfect (kappa range .71-.89). Coders with clinical skills could interpret information to determine injury severity.

In a prospective study, Morgan, Civil, and Schwab (1988) examined the influence of timing and nurse raters on the accuracy of injury severity determination. Scoring of

104 patients (ten penetrating, 94 blunt injury) by nurses was completed within 24 hours of admission and recorded on an edited single page chart constructed from the 1980 revision of the AIS. This single page chart, a list of injuries most commonly seen, contains only 57% of injury descriptions in the AIS 1980. Civil and Schwab (1986) demonstrated that a single page can be used to calculate an accurate ISS in 96% of patients with blunt trauma. Only five minutes of initial instruction were provided. Errors were classified as chart unscorable (2.9%), human inaccuracy (14.4%), human omission (13.5%), and delayed diagnosis (17.3%). Accurate scores were calculated in 54 patients (51.9%). The total human error rate was 27.9%. In a concurrent study of surgical residents scoring within 72 hours, human error was comparable (25%). When scoring was delayed, errors from delayed diagnosis fell to 5%. Scoring will be inaccurate if calculated early since not all injuries are known (MacKenzie et al., 1985). The inpatient chart was found to be more reliable than the emergency department record. By involving direct care givers in scoring, ISS can be corrected as necessary throughout the hospital course.

Age. Age was reported in number of years at the last birthday. It was calculated from the documented birth date on the EMT-P prehospital medical record. If this form was unavailable, the birth date was obtained from the emergency department hospital record.

Height of the fall. The height of the fall was reported in feet. The value was obtained from the height documented on the EMT-P prehospital medical record. This height was not actually measured in clinical practice, but resulted from an estimation by the patient or EMT-P. If the height was reported in stories, the conversion of one story equals 15 feet was used. If the height was reported in number of stairs, the conversion of one stair equals eight inches was used. The EMT-P report was used if more than one height was documented in the medical record. If a range was indicated, the lower end of the range was used.

Landing surface. The landing surface was measured according to a subjective ordinal scale developed by the author which ranged from one to three. Although no previous scale was available, this scale reflects current literature review findings. The landing surface was reported as hard (1: concrete), medium (2: wood), or soft (3: dirt) after information was abstracted from the medical record.

Primary point of impact. The primary point of the body impacted to the surface was measured according to discrete variables of head, trunk, and extremities. It was determined from documentation by the EMT-P.

Whether the fall was broken. Whether the fall was broken was determined by either a positive or negative response by the patient. If neither was indicated, it was reported as unknown.

Intention. Intention was measured as unintentional, intentional (other), and intentional (self). It was obtained from the documentation of the patient's statement of intent. If intention was not indicated, it was reported as unknown.

Alcohol ingestion. Two aspects of alcohol ingestion were obtained from the medical record. Attempts were made to identify acute alcohol ingestion by the results of an estimation of the plasma alcohol level calculated from the plasma osmolality. Increments in plasma osmolality caused by a unit increase in plasma alcohol are linear (Beard, Knott, & Fink, 1974). Plasma osmolality was measured with biomedical machinery in the laboratory. Although alcohol is the most common cause of an elevated plasma osmolality, there are other causes which include elevated Blood Urea Nitrogen, elevated plasma Glucose, and use of Mannitol (Schwartz, Safar, Stone, Storey, & Wagner, 1986). No subject within this study demonstrated any of these criteria on initial presentation. Since only 75 of the subjects had a plasma osmolality drawn, these data were not used in the regression model. Acute alcohol ingestion, therefore, was determined by the subjective documentation of alcohol on the victim's breath. This subjective interpretation provided a beginning association of variables. Prior alcohol ingestion was identified from the documentation of chronic alcohol ingestion in the social history. This measurement may also help identify future questions concerning outcome effects from chronic alcohol ingestion.

<u>Procedure</u>

After research approval by appropriate Committees on Human Research, a total of 233 potential subjects was identified. Attempts were made to compile a list of names and medical record numbers of these patients who fell or had an incompletely documented mechanism of injury suggestive of a fall. This complete list allowed a review of all medical records of patients who fell. Once a patient entered the trauma center, a name and medical record number was written on the base station hospital record by the clerical staff. These forms were stored chronologically in file cabinets within the base station. The names and medical record numbers for 189 patients were identified from the base station records. Of this number, seven patients did not have a fall. In an attempt to identify the remaining 44 patients, 33 were identified from the MICN log, located at the clerk's desk. The names and medical record numbers for the remaining 11 patients were unavailable, therefore, they were not included in the study. Only one of these patients fell greater than 20 feet (65 feet). This extensive review of potential victims resulted in 215 subjects for the analysis.

The researcher reviewed each identified chart in the trauma center medical records office. Subjects were identified and selected when the chart review indicated sample inclusion criteria. The retrospective review continued until all medical records of patients who fell or may have fallen from July 1, 1988 through December 31, 1988 were reviewed.

During the chart review, the researcher observed for evidence of a fall. When there was documentation of a fall, research variables were tallied on the data collection form. For victims that died, injuries were tallied from autopsy reports located in the medical examiner's office. The data collection forms were taken to the Trauma Nurse Clinician's office for calculation of AIS and ISS results based on the documented injuries on the worksheet. Once the data collection forms were completed, they were taken to a computer resources laboratory for data entry by the investigator.

Data Analysis

Descriptive and inferential statistics were calculated using statistical software. The researcher observed for data entry errors by examining every seventh observation for accuracy and the frequency distributions for outliers. The sample was described by descriptive statistics of frequency and means. A stepwise regression model was used to evaluate the degree to which mechanism of injury defining characteristics predicted injury severity. Once this was determined, the variables of age and alcohol ingestion were entered into the regression to identify their influence on injury severity.

CHAPTER IV

Results of the Study

Introduction

This section contains the study findings. The results are described by discussing the sample characteristics and data involving the mechanism of injury, alcohol ingestion, and injury severity. Results of a correlation matrix are presented concerning the research variables. Statistical tests and findings related to the research questions are described and concluded with a summary of the results.

Sample

A total of 215 patients involved in a fall within a six month period from July 1 to December 31, 1988 were included in the analysis. The descriptive data for the sample are illustrated in Table 1. There were 149 males and 66 females. They ranged in age from zero to 91 with a mean age of 45.4 and a standard deviation of 23.0. Nearly all (93%) were adults aged 18 or older. Only 15 victims did not survive their falls.

Mechanism of Injury

The defining characteristics of the mechanism of injury of falls included: height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention. These data are illustrated in Table 2. The height of the falls ranged in feet from zero to 90 with a mean of 12.2 feet and a standard deviation of 16.8. Most (78%) victims fell less than 20 feet. A total of 65

Table 1

Description of Demographic Variables For Patients Who Fell (N = 215)

	Frequency	Percent (%)
Age		
Over 80	23	11
71-80	16	7
61-70	17	8
51-60	27	12
41-50	30	14
31-40	40	19
21-30	39	18
11-20	9	4
1-10	12	6
Under 1	2	1
Gender		
Male	149	70
Female	66	30

Table 2

Description of Mechanism of Injury For Patients Who Fell

(N = 215)	n	Frequency	Percent (%)
Height	209		
0		65	31
1-20		110	53
21-40		17	8
41-60		12	5.5
61-80		4	2
81-100		1	0.5
Landing Surface	170		
Hard		89	52
Medium		67	40
Soft		14	8
Primary Impact	155		
Head		77	50
Trunk		46	30
Extremeties		32	20
Fall Broken	137		
No		122	89
Yes		15	11
Intention	207		
Unintentional		180	87
Intentional: other		10	5
Intentional: self		17	8

subjects (31%) fell at zero feet. More than half (52%) landed on a hard surface. The head was the primary point of impact for 77 victims. Only 15 victims broke their fall. Most (87%) of the falls were unintentional.

Alcohol Ingestion

Acute and chronic alcohol ingestion were both examined (see Table 3). A total of 75 patients had a serum osmolality drawn, therefore, an estimated BAL was available for only 35% of the total sample. Of this number, 50 demonstrated an estimated BAL 100 mg/dl or greater. The presence or absence of alcohol on the breath was more readily available for 214 patients. A third (36%) had alcohol on their breath during the initial assessment. A previous history of alcohol ingestion was present in 58 cases (28%).

Injury Severity

The injury severity data are illustrated in Table 4. The highest possible ISS is 75, the lowest is zero. The mean score was eight with a standard deviation of 12. The range of the scores was zero to 75.

Intercorrelation of Variables

A Pearson correlation coefficient, *r*, was used to determine the relationship between ISS and height of the fall, landing surface, primary point of impact, whether the fall was broken, intention, age, and alcohol ingestion. The significance criterion selected was an alpha less than .05. The correlation data are illustrated in Table 5. The

Table 3

Evidence of Alcohol Ingestion For Patients Who Fell

(N = 215)	Frequency	Percent (%)
Alcohol on Breath		
No	136	63.5
Yes	78	36.5
	n = 214	
BAL 100 mg or more		
No	25	33
Yes	50	67
	n = 75	
Chronic Ingestion		
No	148	72
Yes	58	28
	n = 206	

Note. BAL = Blood alcohol level.

Table 4

Frequency Distribution of Injury Severity Scores For Patients Who Fell (N = 215)

	Frequency	Percent (%)
ISS		
0-15	182	85
16-30	22	10
31-45	6	3
46-60	3	1
61-75	2	1

Note. ISS = Injury Severity Score.

Table 5

Intercorrelations Between ISS and Independent Variables For Patients Who Fell (N = 215)

	Mechanism of Injury				
	Height	Landing Surface	Point of Impact	Fall Broken	Intention
r	.71	-.28	.15	-.08	.44
p	.00*	.00*	.05	.37	.00*
n	209	170	155	137	207

	Age and Alcohol Ingestion			
	Age	ETOHbrth	ETOHBAL	ETOHhx
r	.04	-.13	-.24	-.04
p	.60	.05	.04*	.58
n	214	214	75	206

Note. ETOHbrth = alcohol on breath, ETOHBAL = BAL 100 mg/dl or more, ETOHhx = chronic alcohol ingestion.

*$p < .05$

results indicated there was a positive relationship between ISS and height of the fall ($r = .71$, $p = .00$, $n = 209$). Nearly a third (31%) of the sample fell at zero feet. To determine whether this influenced the relationship between ISS and height of the fall, the correlation was computed after those with a height of zero were deleted. The relationship was not influenced ($r = .69$, $p = .00$, $n = 144$). There was also a positive relationship between ISS and intention ($r = .44$, $p = .00$, $n = 207$). A negative relationship was found between ISS and landing surface ($r = -.28$, $p = .00$, $n = 170$), and BAL 100 mg/dl or greater ($r = -.24$, $p = .04$, $n = 75$).

Findings Related to the Research Questions

The primary research question, "What is the individual and total percentage of the variance in injury severity that is explained by mechanism of injury of falls?" was examined by using a stepwise regression model to evaluate the degree to which these defining characteristics predicted the ISS.

The stepwise regression was used in a sample with complete data (n = 104) to determine the statistical significance of the relationship between injury severity and the following regressors: height of the fall, landing surface, primary point of impact, whether the fall was broken, and intention. This data would indicate which defining characteristics of the mechanism of injury of falls are essential information for the trauma nurse caring for victims of falls. A forward selection introduced height as the statistically most important regressor for the overall model (*R*-square = .45, df = 1, 103, *F* = 83.55, *p* = .00). Height made a large contribution in raising *R*-square. Landing surface was the next variable chosen to add to the model (*R*-square = .49, df = 2, 102, *F* = 48.14, *p* = .00). This change in *R*-square was statistically significant (*R*-square change = .04, *F* = 7.48, *p* = .00). Primary point of impact, whether the fall was broken, and intention failed to significantly increase the percent of explained variance.

The second research question, "What is the degree to which age and alcohol ingestion further explain the variance in injury severity after the mechanism of injury variables are accounted for?" was examined by adding these new variables to the stepwise regression model.

Since only height of the fall and landing surface were statistically significant, a new stepwise regression model was used to determine the statistical significance of the relationship between injury severity and height of the fall, landing surface, age, acute alcohol on the breath, and chronic alcohol ingestion. Primary point of impact, whether the fall was broken, intention, and acute BAL were not entered into the new model, therefore a larger proportion of the sample was included in the analysis (n = 157). Once again, a forward selection introduced height as the statistically most important regressor for the overall model (R-square = .54, df = 1, 156, F = 184.77, p = .00). Landing surface was chosen next in sequence (R-square = .57, df = 2, 155, F = 104.01, p = .00) Again, the change in R-square was statistically significant (R-square change = .03, F = 11.59, p = .00). Age was the next regressor entered to add to the explanation of the variance (R-square = .59, df = 3, 153, F = 73.33, p = .00). This change in R-square was statistically significant (R-square change = .02, F = 5.71, p = .01). The last regressor entered into the model was chronic alcohol ingestion (R-square = .59, df = 4, 153, F = 55.78, p = .00). The increase in explaining ISS by chronic alcohol ingestion was not statistically significant (R-square change = .01, F = 1.89, p = .17).

Summary of Results

A stepwise regression model was used to determine the proportion of the variance that was explained by the mechanism of injury of falls (see Table 6). Height of the fall explained 45% and landing surface further explained 4%, resulting in a total of 49% of the variance in injury severity explained. Primary point of impact, whether the fall was broken, and intention failed to further explain the variance. Due to this finding, primary point of impact, whether the fall was broken, and intention were removed from the model when examining the influence of age and alcohol ingestion. In this larger sample, height of the fall explained 54%, landing surface explained 3%, and age explained an additional 2%, resulting in a total of 59%

of the variance in injury severity explained. Although significant, the contribution of adding age to the mechanism of injury of falls to explain injury severity was minimal.

Table 6

Summary of the Variance in ISS Explained by Independent Variables For Patients Who Fell

Mechanism of Injury		
(n = 104)	Height	Landing Surface
% Explained	45	4
F	88.80	7.48
p	.00*	.01*

Mechanism of Injury, Age, and Alcohol Ingestion				
(n = 157)	Height	Landing Surface	Age	ETOHhx
% Explained	54	3	2	0
F	203.94	11.59	5.71	1.88
p	.00*	.00*	.02*	.17

Note. ISS = Injury Severity Score, ETOHhx = chronic alcohol ingestion.

*$p < .05$

CHAPTER V

Discussion

Basis of the Study

The intent of this study was to determine the percentage of the variance in injury severity that was explained by the mechanism of injury of falls, age, and alcohol ingestion. The research questions were derived from the conceptual model and literature review. They were approached by measuring the variance using a stepwise regression model. The results indicated that height of the fall explained the majority of the variance in injury severity. Only landing surface and age further explained a small amount of the variance.

A correlation matrix revealed individual relationships between ISS and the independent variables. The injury severity was more likely to increase as the height of the fall increased. This has face validity and was supported by Reynolds et al. (1971) and Bostman (1987). In addition, the injury severity was more likely to increase when the primary point of impact was the head. This finding has face validity due to the key functions of the central nervous system and was supported by Snyder (1963), and Cummings and Potter (1970). Interestingly, if the fall was intentional or the BAL was greater than 100 mg/dl, the victim was more likely to have a lower ISS. Ciccone and Richman (1948), Snyder (1963), and Seymour et al. (1987) have demonstrated similar findings. These studies have suggested that a relaxed neuromuscular system common with intention and acute alcohol ingestion resulted in less injury severity.

Overall Meaning of the Findings

It is believed that injury severity is related to the interaction among human factors, energy sources, and the physical and social environment. Human factors examined in this study included age and alcohol ingestion. Energy sources and environmental factors were included by examining the defining characteristics of the mechanism of injury of falls. The data analysis from this study revealed that height was the most important factor determining injury severity. This finding is clinically significant as height of the fall is easily determined and commonly reported to the trauma nurse. Height is currently used as the standard criterion determining severity of injury for victims of falls. Results from this study indicate that height of the fall is an essential defining characteristic of the mechanism of injury of falls. Lewis et al. (1965) and Bostman (1987) have presented similar findings. On the contrary, case studies by Snyder (1963), Kazarian et al. (1976), and Layton et al. (1981) suggested that landing surface was more important than height in determining injury severity. There were few falls from great heights in this study.

A second important finding was that landing surface contributed an additional small amount in determining injury severity. As the landing surface increased from soft to hard, the injury severity increased. This finding is clinically significant. This indicates that the landing surface is important in determining injury severity, but not nearly as fundamental as height of the fall. Since knowing the landing surface assists in determining injury severity, it is important for the trauma nurse to determine the landing surface.

The third finding was that the influence of age in determining injury severity was minimal. Although age was statistically significant, it added little in determining injury severity. This finding contradicts most studies reviewed in Chapter II, including Baker et al. (1974), Baker and O'Neill (1976), and Bull (1982). Most showed that mortality, a broader variable, was increased in the elderly, yet, only Bull (1982) examined the ISS.

Fourth, acute or chronic alcohol ingestion, as defined in this study, failed to add in explaining the variance in injury severty. This finding was supported by Ward et al. (1982) and Waller et al. (1986). In this study, alcohol ingestion (BAL 100 mg/dl or greater) examined independently was related to injury severity. It was not included in the regression model along with mechanism of injury since only 35% of the sample had an estimated plasma osmolality drawn.

The analysis revealed that the other mechanism of injury defining characteristics (primary point of impact, whether the fall was broken, and intention) failed to add in the explanation of variance in injury severity. This is contrary to findings in classical research by DeHaven (1942) and Snyder (1963), however, this study's data set was not extensive. It was evident during data collection that these variables were not as readily available in clinical practice. Efforts to isolate and study these variables prospectively in future research are indicated.

The overall findings are notable since they confirm the importance of height of the fall and landing surface using inferential statistics. Although other researchers have demonstrated the significance of these variables, this study used a regression model to indicate percentages and relationships among variables.

Limitations of the Study

The possibility exists that height of the fall was not measured accurately. The measurement resulted from an estimation. However, error seems unlikely as a standard conversion from number of stories to feet was used with consistency. When the fall was less than one story, the potential error of a few feet seems insignificant. The retrospective review provided clinically available information.

There was a possibility that intention of the fall was not measured accurately. This variable was dependent on a truthful response from the patient. A victim may not admit to an intentional fall for fear of retribution. This seems highly unlikely. For those victims that died, the medical examiner's investigation provided clarity of intention.

Lastly, acute and chronic alcohol ingestion may have been measured inaccurately. Both variables were dependent on the subjective interpretation of those caring for victims of falls. The entire medical record was abstracted for evidence of the variables. Accuracy would have been enhanced by using a blood alcohol level to determine acute alcohol ingestion, however these levels were unavailable for the entire sample. Only 75 subjects had an osmolality drawn, allowing the estimation of the blood alcohol level. The influence of alcohol ingestion awaits further study.

An additional challenge to the validity of the study concerns the inclusion of victims that fell down stairs. This mechanism of injury differs slightly from deceleration during vertical falls as the body tumbles down the stairs. Further discrimination may be indicated. The sample included only 38 victims that fell down stairs and none of these falls were from great heights.

Furthermore, insufficient data existed for observations in the study which may have hampered the ability to detect statistical significance. For example, most of the victims fell less than 20 feet, with nearly a third at zero feet. Only a small number broke their fall or had an intentional fall. However, the overall sample size was large enough to meet assumptions of the regression model used in data analysis.

Summary of Results

Validity issues were presented in an attempt to explain limitations of the study. These limitations included measurement error, inaccurate sampling, and unrepresentative data.

Relevance to Nursing

Trauma nurses frequently encounter patients that fall. Two possible implications for nursing practice emerge from the analysis of the results. First, it is evident that of all the defining characteristics of the mechanism of injury of falls, height of the fall and landing surface are pivital in determining injury severity. This essential information can be used by trauma nurses when planning and implementing care of patients who fall. Life-saving interventions may be instituted early despite initial hemodynamic stability.

Second, victims of falls with and without alcohol ingestion require the same index of suspicion of injuries. The assumption must not be made that alcohol ingestion lessened the injury severity. Trauma nurses may be required to perform more frequent assessments for victims with alcohol ingestion because of the patient's alteration in consciousness.

Implications for Future Study

After examining results from this study, future research designs are apparent. A prospective study of the mechanism of injury of falls would help ensure the complete collection of research data and confirm findings from this study. Information concerning the defining characteristics may be used to help develop strategies for the prevention of falls.

Now that it is known which defining characteristics during falls are important in determining injury severity, the effects of mechanism of injury on specific body systems should be explored. Certain body systems may be more susceptible to injury during a fall. Next, injuries to individual organs may be categorized to demonstrate patterns of injuries. This would further increase the specificity of trauma assessment and treatment, resulting in trauma nursing protocols for patients who fall.

Although injury severity is one measure of the impact of trauma, a more comprehensive indicator would document the severity of disability and the outcomes of trauma care and rehabilitation. Future research should examine the patient's ability to perform everyday activities in the range considered normal. This would provide data to allow advanced rehabilitation practices to emerge, resulting in the opportunity for patients to achieve maximal physical, social, psychological, and vocational recovery.

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Appendix A

Mechanism of Injury

Mechanism of Injury

1. Falls 20 feet or more
2. Crash speed 20 mph or more: 30 inch deformity of automobile
3. Rearward displacement of front axle
4. Passenger compartment intrusion 18 inches on patient side of car, 24 inches on opposite side of car
5. Ejection of patient
6. Rollover
7. Death of some car occupant
8. Pedestrian hit at 20 mph or more

Appendix B

Base Hospital Record

...AGE HOSPITAL RECORD

AGE (8-9) ______ SEX: ☐ M 1 (10) ☐ F 2

...TE ...) ______

...ME ...-14) ______

...UN # ...-20) ______

...RA # ...-23) ______

...A ______

AMBULANCE CO (7)

☐ DEPT OF PUBLIC HEALTH 1

AMB # ______

☐ S/F AMBULANCE 2

☐ MERCY PENINSULA 3

☐ KING & AMERICAN 4

☐ MEDEVAC 5

...ESTINATION: ☐ SFGH ...-25) ☐ OTHER ______ 2-23

B/P (27-31)	PULSE (32-34)	RESP (35-36)
/		
/		
/		

EKG (37) ☐ NSR 1 ☐ OTHER 2 (Specify)

...REATHING (38)	PUPIL (39)	SKIN COLOR (40)	MOIST/TEMP (41)
☐ EQUAL 1	☐ PERL 1	☐ NORMAL 1	☐ DRY 1
☐ CLEAR 2	☐ PINPOINT 2	☐ PALE 2	☐ MOIST 2
☐ SHALLOW 3	☐ DILATED 3	☐ ASHEN 3	☐ COLD 3
☐ RETRACTIVE 4	☐ REACTIVE 4	☐ FLUSHED 4	☐ COOL 4
☐ ABSENT 5	☐ NON-REACT 5	☐ CYANOTIC 5	☐ WARM 5
☐ WHEEZE 6	☐ R>L6	☐ JAUNDICED 6	
☐ LABORED 7	☐ L>R7		
☐ OTHER 8			

PMH:

ALLERGIES:

MEDICATIONS:

...YE OPENING (42)	VERBAL (43)	MOTOR (44)	AIRWAY (56)	IV FLUIDS (57)	PROCEDURE (58-63)
☐ SPONTANEOUS 1	☐ ORIENTED 1	☐ OBEYS COMMANDS 1	☐ O_2 ______ L/MIN 1	☐ D_5W 1	☐ DRAW BLOODS 1
☐ TO VOICE 2	☐ CONFUSED 2	☐ PURPOSEFUL 2	☐ NASAL CANNULA 2	☐ PLASMALYTE 2	☐ MONITOR 2
☐ TO PAIN 3	☐ INAPPROPRIATE WORDS 3	☐ WITHDRAWS TO PAIN 3	☐ MASK 3	☐ NORMAL SALINE	☐ SPINAL PRECAUTIONS 3
☐ NONE 4	☐ INCOMPREHENS WORDS 4	☐ FLEXION TO PAIN 4	☐ BAG ASSIST 4	RATE	☐ SPLINTS 4
	☐ NONE 5	☐ EXTENSION TO PAIN 5	☐ E O A 5	☐ TKO	☐ MAST 5
		☐ NONE 5	☐ ENDOTRACH 6	☐ WIDE	☐ CPR MIN. ______ 6
				☐ FLUID CHALLENGE ______ ML	☐ DEFIB (Prior to contact) 7
				TOTAL ______ ML	☐ OTHER ______ 8

...EDICATION Time	Narcan IM IVP (45)	Dextrose 50% IVP (46)	NTG gr 1/150 S.L. (47)	Lidocaine 2% IVP (48)	Alupent via neb. (49)	Lasix 20mg IVP (50)	$NaHCO_3$ IVP (51)	Epinephrine IVP (52)	Atropine IVP (53)	DC Countershock (54)	Other (55)	RESPONSE/ADDITIONAL V.S./RHYTHMS
												☐ HOSPITAL NOTIFIED

...TIOLOGY: (...6) TRAUMA ☐1 ARREST ☐2 RESP. ☐3 CARDIAC ☐4 OB/GYN ☐5 NEURO ☐6 GI ☐7 TOXIN ☐8 AMS ☐9

(64) RADIO #1 ☐ #2 ☐ ND ☐ CORD ☐ LAND LINE ☐

☐ RADIO FAILURE (65) ☐ EKG FAILURE (66) ☐ MULTI-RUN (67)

...OG ...UMBERS 53510

SIGNATURE ______ MICN# (68-70)

...00F101

Appendix C

Determination of Kinetic Energy

d = 60 feet free fall

v = 0 beginning velocity

a = 32 feet/second acceleration

w = 150 pounds

$v_t^2 = v_o^2 + 2ad$

$v^2 = 0 + 2(32)(60)$

$v^2 = 3,840$ feet/second

m = 150/32

m = 4.69

$KE = mv^2 / 2$]

KE = 4.69(3,840)/ 2

KE = 9,005 foot pounds

Appendix D

Data Collection Form

Data Collection Form

1. __________ Medical record number (8)

2. __________ Date (6)

3. __________ Age (2)

4. __________ Gender (1)

   1--male

   2--female

5. __________ Height of fall (3)

6. __________ Surface (1)

   1--Hard (Concrete)

   2--Medium (Wood)

   3--Soft (Dirt)

7. __________ Primary point of body impact (1)

   1--head

   2--trunk

   3--extremities

8. __________ Fall broken (1)

   0--No

   1--Yes

9. __________ Intention (1)

1--Untentional

2--Intentional (other)

3--Intentional (self)

10. __________ Acute alcohol on breath (1)

0--No

1--Yes

11. __________ Acute estimated plasma alcohol level 100 mg/dl or greater (1)

0--No

1--Yes

12. __________ Chronic alcohol ingestion (1)

0--negative history

1--positive history

13. __________ Injury Severity Score (2)

14. __________ Hospital days (3)

15. __________ Survival (1)

1--Lived

2--Died

Appendix E

Worksheet

Worksheet

__________Plasma Osmolality

__________ Calculated Osmolality

[2(Na) + Glu/18 + BUN/2.8]

mEq/L mg/dl mg/dl

__________ Osmolality gap

(Plasma Osm - Calculated Osm)

__________ Estimated plasma alcohol level

(Osm gap x 4.6)

Injury______________________ Body region___ AIS___ ISS___

______________________ ___ ___

______________________ ___ ___

______________________ ___ ___

______________________ ___ ___

______________________ ___ ___