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PEDIATRIC AND ADULT BICYCLE INJURIES ON MACKINAC ISLAND: A THREE YEAR REVIEW

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Elizabeth Anne Klein

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# PEDIATRIC AND ADULT BICYCLE INJURIES ON MACKINAC ISLAND: A THREE YEAR REVIEW

By

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ABSTRACT

PEDIATRIC AND ADULT BICYCLE INJURIES ON
MACKINAC ISLAND: A THREE YEAR REVIEW

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The purpose of this study was to examine the occurrence of bicycle injuries in both the pediatric and adult populations on Mackinac Island from 1994 through 1996 as it relates to occurrence, anatomical site and injury severity. Additional aspects of the study included a look at the accident site location, along with time of day and day of week for each incident. All accident reports were reviewed during this time and this study revealed that adults were involved in a greater number of accidents, and a greater percentage of them required Emergency Medical Service transport to medical care. Injuries sustained by the adult population tended to be more severe. For both groups the greatest percentage of injuries were located in the upper extremity, followed by the face and head. The majority of accidents occurred, for both groups, from 12 noon to 8 p.m. and were in high traffic areas. Implications for establishing safety interventions are discussed.

## ACKNOWLEDGMENTS

I wish to thank my thesis committee, Dr. Manfred Stommel, chair, Dr. Mary Hughes and Patty Peek for their encouragement and support of this study. I also wish to thank the College of Osteopathic Medicine at Michigan State University for inviting me to participate in this study, with deep appreciation to Dr. Mary Hughes for her continued support.

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# INTRODUCTION

Bicycle injuries are widespread in the United States as well as many parts of the world. Mackinac Island is a small island located off the northern coast of the lower peninsula of Michigan, where bicycles are the major mode of transportation and cars as well as other motorized means of transportation are prohibited. The island is also a very popular tourist destination which receives visitors from all over the world who come to see "things as they used to be" and who often ride a bicycle to tour more remote portions of the island. This site was chosen because it was thought to provide a unique environment in which to study a large population of bicycle riders and related injuries unaffected by motor vehicles, to determine types, severity and location of injuries suffered by riders on this island. This resort area provides a rare opportunity for studying the effects of bicycling injuries in the unusually vulnerable tourist population. This vulnerability appears to be related to lack of preparation and a false sense of security in a recreational environment where no formal safety programs have been instituted to protect the rider. Proper safety equipment may reduce the frequency and severity of injuries though there may be multiple barriers to the use of this equipment.

## Problem Statement

Bicycles are increasingly being used as a means of recreational transportation. The nurse practitioner, therefore, will be called on to treat many of the injuries resulting from accidents involving bicycles. In addition an important role of the APN will be to develop and promote programs that assist individuals and communities in reducing and preventing bicycle-related injuries. However, an understanding of injury patterns must precede the development of such programs. The purpose of this study is to identify and compare occurrences and severity of bicycle-related injuries in the pediatric and adult age groups reported to the Mackinac Island Police Department during the three year study period, from 1994-1996. Of all the injuries sustained by bicycle riders, head and upper face injuries appear to be the most preventable and will be looked at in detail. In addition, sites of accidents will be plotted on a map of the island for each age group. Mackinac Island was chosen as the site of the study because there are a large number of cyclists and no motorized vehicles.

Specific questions to be addressed in this study are:

1. Of the bicycle injuries reported, how many occur in the pediatric and adult age groups?

2. Where on Mackinac Island do most accidents occur?
    a. Are there significant variations in the number of accidents across week days?
    b. Are there significant variations in accidents by time of day?
3. What is the frequency and anatomical location of injuries reported in the pediatric and adult bicycle rider?
    a. What is the severity of these injuries among the pediatric and adult persons reporting their bicycle injuries?

## Conceptual Framework

Concerning a framework for this study, investigation of injury patterns in pediatric and adult bicycle riders can most appropriately be understood in terms of Nola Pender's Health Promotion Model (Pender, 1996). The Health Promotion Model (HPM), designed as a competence or approach-oriented model with a wellness-oriented framework, guides the Advanced Practice Nurse toward a holistic approach to health promotion. It was originally proposed as a framework through which nursing and behavioral science perspectives were integrated to focus on factors influencing health behaviors, see Figure 1.

The basis for the HPM derives from the integration of a number of constructs from the Expectancy-Value Theory and the Social Cognitive Theory (Pender, 1996). The Expectance-Value Theory is a model of rational and economic behavior,

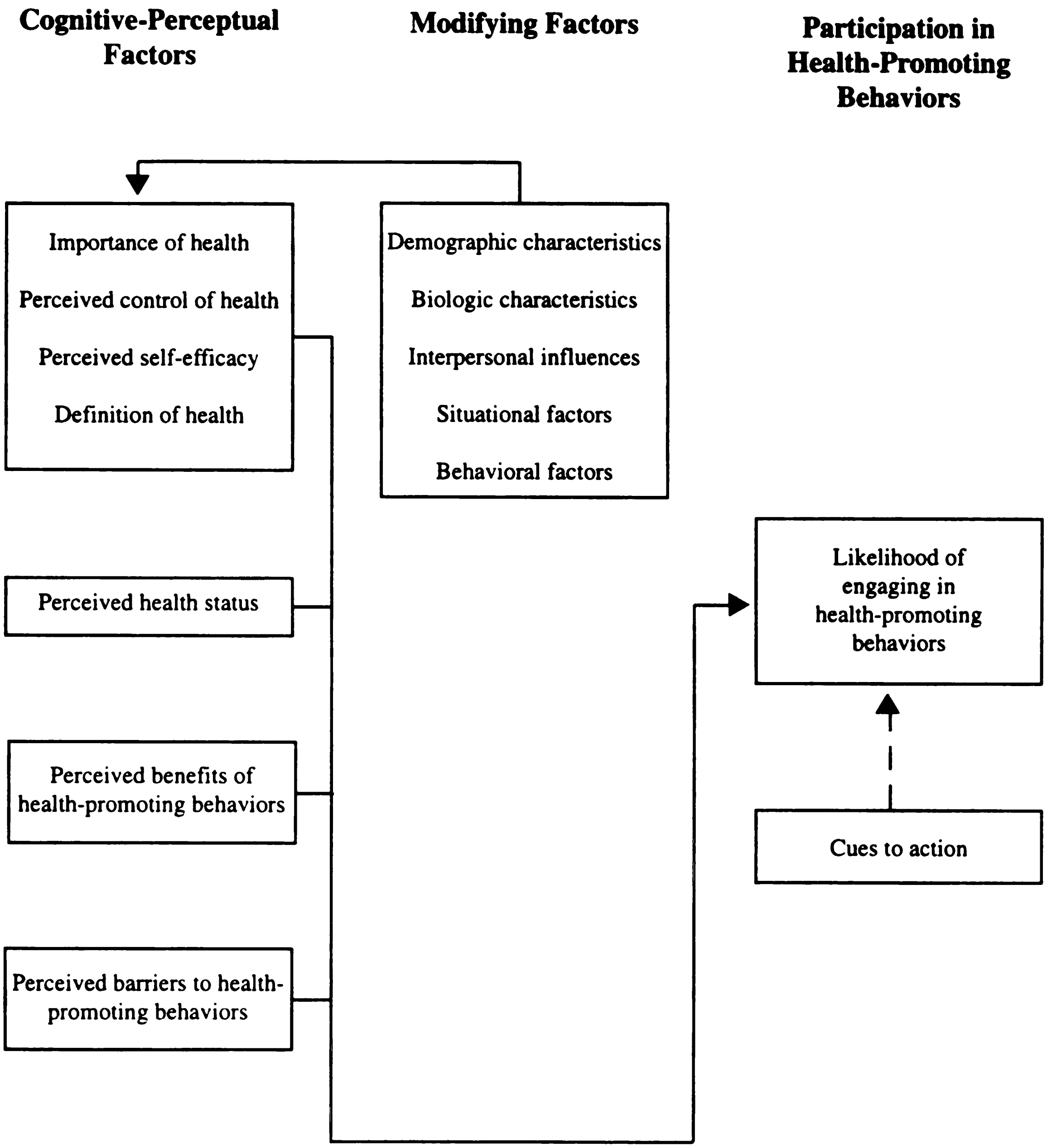


Figure 1. Pender's Health Promotion Model (1996 p. 52).

meaning that it assumes that the individual will persist with a behavior as long as the outcome has a positive personal value and, based on present available information, will bring about a desired outcome. The Social Cognitive Theory is an interactional model of causation according to which environmental events, personal factors and behavior, shaped by both internal forces and external stimuli, and act as reciprocal determinants of each other (Pender, 1996). A critical perception of the HPM is that the individual or community does not use fear or potential threat as a source for behavior change.

The likelihood of an individual participating in health-promoting behaviors is influenced by cognitive perceptual factors. These include an individual's definition of health significance, and one's perceived control over it. Current perceived health status understanding the benefits of and the barriers to health-promoting behavior, along with the person's perception as to their ability to carry out these behaviors, all alter the behavior outcomes. Other influences on the cognitive-perceptual factors include demographic variables such as age and sex. Biological characteristics, interpersonal influences and situations, along with behavioral factors also act as modifying agents of cognitive-perceptual factors. Furthermore, cues to action, described as stimuli that can trigger health-promoting behavior can originate from internal or external sources. For the purpose of this study, Pender's HPM will be used with regards to the Advanced Practice Nurse (APN) implications for practice and the development of safety interventions that act as external cues to action that promote health behaviors, see Figure 2.

Rationale for Model Use

The Health Promotion Model has been used in a variety of settings to help explain and predict health-promoting behaviors. Pender, Walker, Sechrist, and Stromborg, (1990), determined through the use of the HPM that individuals who reported more health-promoting behaviors viewed health as high-level wellness rather than the absence of illness, and also that health was affected by significant others, not by chance or luck. Additionally, the HPM was determined useful in both adult and adolescent studies in predicting and explaining exercise behaviors, (Pender, 1996). According to Farrand and Cox,(1993), health behavior of children is influenced by intrinsic motivation, self-esteem, personal health perception, and adult or parental influences, with health perception being the single consistent variable affecting health behavior. Further studies of this model show great promise, but little research has been done that examines external cues to action as it relates to the study in this paper.

Pender's HPM, (1996), is an appropriate model for studying injury incidence rates because it provides the Advanced Practice Nurse (APN) with a framework for understanding health behavior in settings outside the

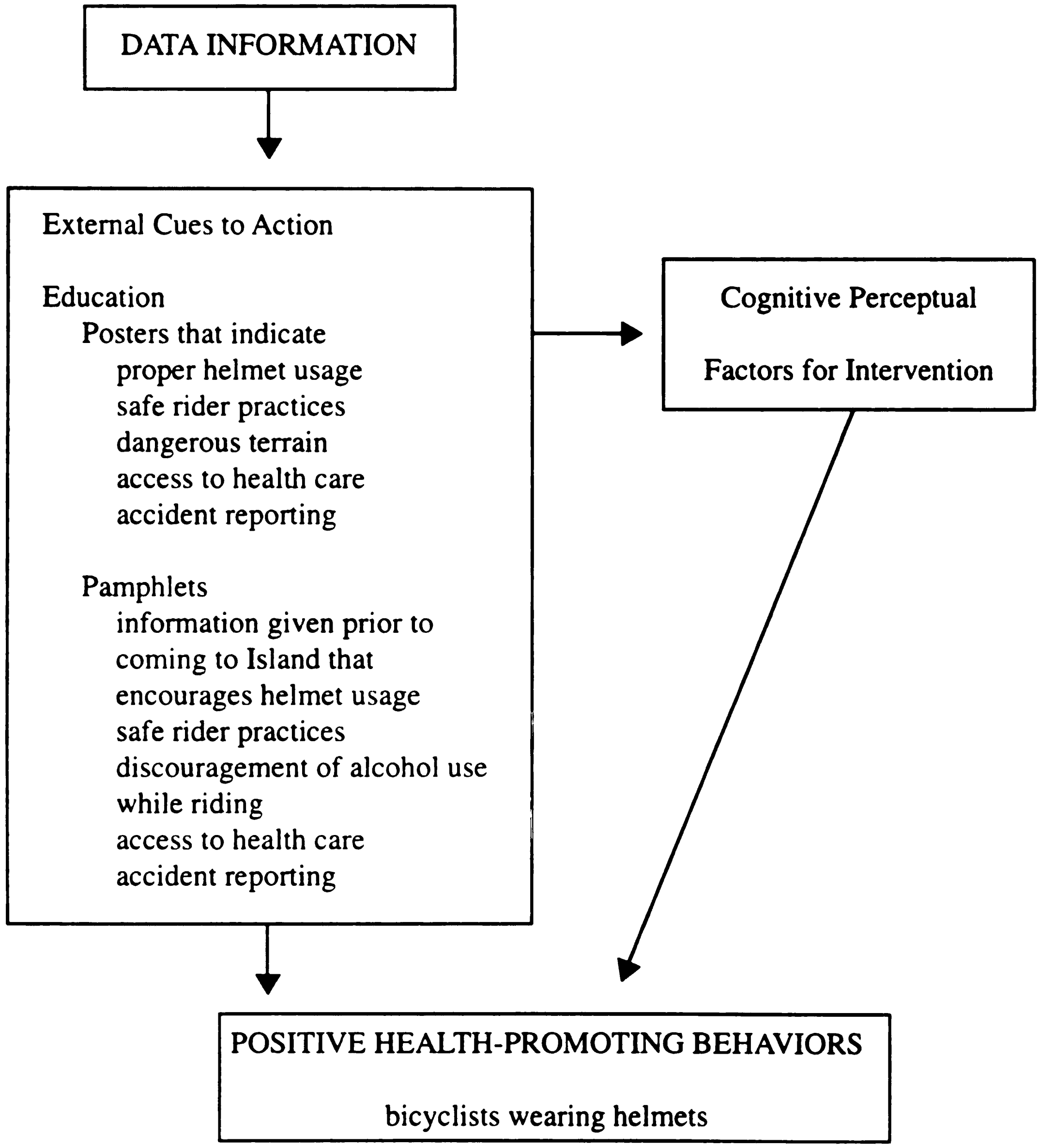


**Figure 2. Adaptation of Pender's Health Promotion Model (1996)**

individual's everyday environment. Because of the holistic nature of this model, the APN's understanding of health behavior as a combination of influences coming from self, significant others, the community, and the environment is enhanced. Armed with this knowledge, the APN can develop and direct programs towards increasing the level of well-being of the individual, family or community.

Health motivation, a key concept instrumental in predicting health behavior, is defined as a generalized state of intent that results in behaviors to improve or maintain health (Becker, 1974). By combining the concept of health motivation with health beliefs, defined as attitudes or thoughts an individual has towards health, the APN is able to apply the HPM to data collected from empirical research to promote positive health behavior through stimulating external cues to action.

As Pender (1996) emphasizes, external cues can come from a variety of sources; interaction with significant others, communications from the media and visual input. Additionally, Pender (1996) states that by expanding the number and frequency of external cues, health-promoting behavior is prompted with increased frequency and regularity of positive health practices. Adapting Pender's HPM externally generated cues to action can also refer to information developed and presented to the individual or community which could directly prompt positive-health behavior or alter the cognitive perceptual factors that lead to the promotion of these behaviors, see Figure 2. Cues to action may stimulate behavior change independently or be used as a foundation to assist the community or individual in modifying their cognitive-perceptual factors. By providing the individual or community with data stating injury potential and prevalence of accidents at particular sites one is likely to raise the general external cues to action as it relates to implications for health-promoting behaviors and awareness about the likelihood and dangers of physical accidents. These external cues to action provide the building blocks by which the individual or community can develop a plan of action to promote health and safety allowing the bicyclists to take necessary action to ensure a safer riding experience. This study can be used to increase the level of awareness especially in individuals unfamiliar with their surroundings, like visitors in recreational areas.

The impact of the media should not be overlooked as a means of increasing the number or frequency external cues. Provision of health bulletins based on the results of this study may be a significant means of reaching this objective. Additionally, the use of visual cues, such as signs posted at dock sites encouraging helmet use or along pathways indicating changes in terrain should not be overlooked as important means of promoting the likelihood of the individual altering or engaging in health-promoting behaviors.

## Literature Review

Accidents in the United States are considered the most significant cause of morbidity and mortality in children, accounting for more death than all diseases combined (Ashbaugh, Macknin, & Medendorp, 1995). Bicycle-related crashes are a major cause of injury to children, and researchers note that in a study of 492 active adult bicyclists approximately 50 percent of adult riders have been involved in an accident (Kibuz, Jacobs, Reckling, & Mason, 1986). Though the adult bicyclists may be more experienced, this same study noted that 58.7 percent stated that they were at fault at the time of the mishap. Furthermore, studies have indicated that college students are nearly as accident prone as children (Kibuz, Jacobs, Reckling, & Mason, 1986).

Statistics indicate head trauma as one of the most frequently treated types of bicycle injuries. It has been noted by Noakes (1995) that few cyclists who have either suffered or died as a result of these injuries were wearing adequate helmet protection. Rivara et el. (1994) concluded that the risk of upper head injury was 2.7- fold higher among bicyclists not wearing helmets, and the risk for loss of consciousness was 7.3- fold higher. Rivara further emphasizes that bicycle helmet use has been associated with an injury reduction of approximately 80 percent for upper head and 95 percent for loss of consciousness, reduced hospitalization and decreased occurrence of both serious and non-serious injuries including skull fracture, concussion, and soft-tissue injury to the face.

The empirical evidence relevant to the problem under investigation focuses on the prevalence and severity of injuries associated with bicycle accidents. The literature consistently states that in the United States more than 500,000 people are treated annually for injuries sustained in cycling accidents (Noakes, 1995; Zavoski, Lapidus, Lerer, & Banco, 1995). The literature does not give estimates as to the number of bicyclists who crash but do not seek direct medical assistance for injuries. Bicycling crashes are considered to be a significant cause of morbidity and mortality in the United States, (Sacks, Holmgreen, Smith, & Sosin, 1991). In 1991 Americans owned approximately 105 million bicycles (Rowe, Rowe, & Bota, 1995), but studies did not indicate how many individuals owned more than one bicycle. Though the number owned may overestimate the number of riders at any given time, the literature supports that an estimated 80 percent of school-age children own bicycles (Hu, Wesson, Chipman, & Parkin, 1995), and the use of bicycles, both as a means of transportation and as a recreational sport, has grown worldwide. However, the literature is vague as to who fits into the school-age category and how much variation there is among different countries. Currently the production of new bikes exceeds the production of new cars by 3 to 1 (Henderson, 1995), though most of this is accounted for by China.

Traditionally police records were the main source of information on bicycle-related injuries. A study done by Cross and Fisher (1977) estimated that 2/3 of all bicycle accidents did not get reported. Since 1977, the use of emergency department records combined with police records has provided a much more accurate picture about the number and severity of bicycle accident injuries (Stutts, Williamson, Whitley, & Sheldon, 1990).

Currently each year in the United States, more than 500,000 visits to the Emergency Department are the result of bicycle mishaps (Weiss, 1994). Injuries sustained range from minor bruising, cuts and abrasions to more serious, life-threatening traumas leading to long-term disabilities (Weiss, 1994). It has been estimated that over 40 percent of all bicycle accidents are associated with an injury to the head and face, with most resulting from a simple fall from a bicycle rather than a collision with a motor vehicle. However, more than 75 percent of the cyclists fatally injured die as a result of injuries sustained to the head and neck associated with a collision with a motor vehicle (Naokes, 1995). Multiple studies have demonstrated that bicycle-related deaths resulting from head trauma are almost always the result of intra-cranial hemorrhage. In addition, bicyclists are also at risk for serious maxillofacial injuries including those to soft tissue and bone (Weiss, 1994).

<u>Injury Patterns</u>

Trauma patterns seen in the adult bicyclist predominantly affect soft tissue of the extremities with 9.3 percent of all injuries requiring hospital admissions. Just as significant is the fact that 27.5 percent of such accidents result in missed days at work or school (Kiburz, Jacobs, Reckling, & Mason, 1986). Of all the bicycle-related deaths reported annually, approximately 50 percent occur in individuals under 21, (Weiss, 1994), and exceed the death rate from many other causes receiving much greater public attention. Weiss further states that the death rate from childhood bicycle injuries is approximately the same as that of pre-immunization death rates from the Hemophilus influenza infection which prompted the establishment of a major national immunization program. According to Rivara (1985), if as many children died as the result of football injuries each year as die from bicycle crashes, there would be a strong parental outcry requiring modification of the game. Most studies have focused on trends in bicycle-related injuries in children, all of which provide supporting data indicating that the highest injury rates are generally seen in youths between the ages of 9-15 (Mazurek, 1994; Lofthouse, 1994). Stutts et el. (1990) state in a report of 649 Emergency Department treated bicyclists, males were approximately twice as likely as females to sustain injury of AIS 2 or greater, 22 percent male vs. 12 percent female ($p < 0.01$), with adult riders experiencing a greater percent of their injuries in categories greater than or equal to AIS 2. It is generally well accepted throughout the literature that there are more male riders than female riders (Noakes, 1995). When reviewing data of injury rates from an international perspective it is difficult to ascertain the number of injuries per 100,000 population because most studies dealt with injuries and injury types associated more with cause in certain populations. However one study done in Ontario, Canada between 1989 and 1991 reported boys, between the ages of 11-12 having the highest overall injury and head injury rates (HU, Wesson, Chipman, & Parkin, 1995). All studies have indicated, especially in countries where aggressive tabulation of bicycle-related injures are undertaken, the rate of injury to bicyclists has been increasing (Noakes, 1995).

The trauma registry of the Children's Hospital Medical Center in Cincinnati, Ohio has made preventing bicycle injury its current major initiative. It has studied all pediatric bicycle-related crashes in the state of Ohio from 1991 and 1992, revealing that 419 children were treated for bicycle-related injuries, with 191 children being hospitalized for injuries in 1992 alone. The majority of victims were males between the ages of 5-14 years (Ashbaugh, Macknin, & Medendorp, 1993). This type of reporting, consistent with much of the literature that focuses on injuries in the pediatric population, suggests that males have the highest accident and injury rates. Males between the ages of 10-14 were also reported as having the highest mortality (Mazurek, 1994). These results are consistent with international results indicating boys have a greater injury rate in comparison to girls (Towner, Jervis, Walsh, & Green, 1994).

Few studies haven been done, whether in the United States or abroad, trying to investigate and obtain information regarding injury patterns for adult bicycle riders. Injury patterns seen in the adult bicyclists are predominately soft tissue injuries to the extremities with 9.3 percent of all injuries requiring hospital admissions (Kiburz, Jacobs, Reckling, & Mason, 1986). In earlier study done by Kiburz, Jacobs, Reckling, & Mason, (1986), which looked at crashes involving 492 active adult cyclists who were members of two Kansas bicycle clubs, 46.3 percent of the cyclists had had an accident for which about 60 percent claimed responsibility 34.8 percent of the accidents involve moderate to severe injuries. For how long the people have been cycling at any given outing and where they were cycling may have played a significant role in the injury patterns. The mean cycling experience of these riders was 10.7 years, with lone cyclists accounting for approximately 50 percent of all cycling accidents. A 1989 Oregon study of 311 bicycle-related injuries indicated that, although children accounted for 60 percent of serious accidents, adults accounted for 67 percent of fatalities (Frank, Frankel, Mullins, & Taylor, 1994). Investigation of the literature consistently shows riders under 21 years are involved in the greatest number of cycling accidents, but adult riders over the age of 21 have the most serious accidents. These studies do not report the time spent biking by individuals or their experience riding therefore making it difficult to compare the two populations. Throughout several years of studies the highest injury rate is seen in males, and this trend predominates throughout all age groups (Fife et el., 1983; Goodwin, Parker, & Dudzik, 1994).

When looking at the type of injury sustained in a bicycle crash, early studies indicate the majority are abrasions, lacerations, or contusions. A smaller number of injuries resulted in fractures, with the smallest number being reported as concussions. Later investigations reached similar conclusions, but went into greater depth describing and associating anatomical injury sites not only with severity but also with relevance to age group and sex. The results show that in single-injury accidents, the arm and hand are most frequently involved, followed by the leg, foot, and ankle. In accidents resulting in multiple-site injuries it is interesting to note that the arm and hand once again are injured most frequently, followed by the knee and head. Contusions, followed by lacerations and sprains were the most common injury type noted (Gerberich, Parker, & Dudzik, 1994).

The literature focuses much attention on head injuries as being the most important determinant of mortality and long-term disability in bicycle-related crashes. Noakes (1995) reports head and face injury rates associated with bicycle accidents vary worldwide from 31 to 81 percent with an average of 51 percent. All leading experts agree that the most common head injury noted was a concussion, which accounted for about 54 percent of this type of injury. The next most reported head injury was skull fractures, in about 24 percent of incidents, with intra-cranial hemorrhage seen in approximately 5 percent (Li, Baker, Fowler, & DiScala, 1995). Head injuries as the resulting from bicycling accidents have been documented in national and international studies in part because of the devastating consequences. This type of injury accounts for upwards of 70 percent of fatalities and is the most common discharge diagnosis from hospitals (Zavoski, Lapidus, Lerer, & Banco, 1995). Furthermore, head injuries were found to be one of the most easily prevented injuries in both numbers and severity through the use of a properly worn bicycle helmet. Thompson, Rivara, & Thompson (1996) state that bicycle helmets may be effective in decreasing this type of injury by upwards of 85 percent.

Impact of Safety Equipment

Through the proper use of bicycle safety equipment, the frequency and severity of bicycle-related injuries could be reduced. It is estimated that recreational and commuter riders have a 50 percent chance of injury every year. Because most fatalities involve injuries to the head, a properly worn bicycle helmet is the most important piece of protective equipment that a cyclist can wear (Ellis, Streight, & Mellion, 1994).

Properly fitted, well maintained, and correctly worn personal safety equipment will help decrease the amount and severity of injuries. The bicycle helmet is designed to reduce the risk of head injury in bicycle falls and crashes. As with many sports, equipment designed to prevent injuries associated with sport-specific conditions will limit its overall effectiveness. Therefore the use of a football or motorcycle helmet for bicycling is deemed unwise. The bicycle helmet reduces the force of impact to the head during a fall or crash and helps to prevent head cuts and penetration by sharp objects. It is important that a bicycle helmet be properly fitted in order to remain in place during impact (Ellis, Streight, & Mellion, 1994). Properly worn bicycle helmets are the most readily effective measure available in reducing bicycle-related head injuries (Thompson, Rivara, & Thompson, 1996). Bicycle helmets have been shown in some studies to reduce severe head injuries by about one-third. However, Henderson (1995) states it could be estimated in the 45 percent range, going as high as 85 percent in some areas worldwide. Most experts agree that, regardless of the type of bicycle helmet used in the United States, it will provide substantial protection against head injuries and injuries to the upper and middle face of persons involved in crashes, including those involving motor vehicles. They may, however, have no significant effect on serious injuries to the lower face, (Thompson, Nunn, Thompson, & Rivara, 1996). The use of protective clothing such as cycling shorts and padded gloves can reduce injuries from a scrape in a fall. Other protective equipment includes the use of eye protection to shield the rider from flying objects such as stones, bugs, and other wind-born irritants, along with radiation from the sun. The use of sunglasses per se are not considered to be appropriate because of their poor performance during impact, (Thompson, Nunn, Thompson, & Rivara, 1996).

### Barriers to Use

Though there are many pieces of safety equipment the rider can use, it may not be feasible for the bike rental shops to provide them all. Bicycle safety helmets have been successfully introduced in many countries, including Australia, Great Britain, Denmark, Sweden, and the United States. However, there are several barriers to their use discussed by Seijts, Kok, Bouter, & Klip (1995): first, many individuals feel helmets to be somewhat uncomfortable, particularly, that they trap heat and tend to tangle hair. Secondly, many bikers do not know what to do with the helmet once they stop cycling, for instance, when shopping or dining. Third, negative social pressure is exerted on riders, especially younger riders. In resort areas, additional barriers include not coming prepared for bicycling and not knowing how to access safety equipment.

By looking at the types and severity of injuries sustained on Mackinac Island, determination of the most appropriate safety equipment needed, making this equipment accessible, and educating the rider on its correct use may then be undertaken.

International Studies

Worldwide bicycle utilization has made bicycle-related injuries a significant area of pediatric and adult trauma. It is important to note that the primary use of bicycles in the United States is recreational, whereas in many foreign continents the bicycle is the primary mode of transportation for work as well as pleasure. Motorists are trained at a young age to watch for cyclists on the roadways in countries other than the United States. In the review of studies done in Great Britain, Australia, and the United States, there are some noted differences in the percentages of injuries categorized by anatomical site. The trend shows that the majority of injuries are sustained to the upper extremity followed by head and face. Injuries to the lower extremities are then followed by the least-frequent injuries, those involving the trunk (Ballham, Kotecha, & Bodiwala, 1985; Gerberich, Parker, & Dudzik, 1994). An exception to this was noted in a study examining injuries sustained by off-road bicyclists and competitive riders. Here 90 percent of all injuries involved the extremities, (Pfeiffer & Kornisch, 1995).

Internationally, head injuries from bicycle-related crashes consistently account for the most significant injury types in both children and adult bicycle riders. Australian studies reveal injuries to bicyclists as a significant cause of death and personal injury producing short and long-term disabilities that led to the establishment of strict bicycle safety rules (Henderson, 1995). Likewise in Ontario, Canada, safety regulations were implemented because an estimated 75 percent (n=212) of bicycle-related deaths, from 1986-1991, were the result of head injuries and only 4 percent of those involved wore bicycle helmets at the time of the crash. Over 32 percent of the victims under the age of 15 listed human error as a major cause of these accidents (Rowe, Rowe & Bota, 1995). In the Peoples' Republic of China, where bicycling is a major means of transportation, bicycle mishaps constitute the primary cause of traumatic brain injury in individuals of all ages (Weiss, 1994). Noakes (1995), states that an estimated 1 percent of all Australian children between the ages of 5 and 14 years seek medical attention from hospitals and clinics annually and that 10 percent of United States and Australian visits to emergency departments are for the treatment of bicycle-related injuries. Further studies in Sweden suggest that for all cyclists 700 person-years of work are lost annually as the result of cycling injuries alone, (Noakes, 1995).

Injury Scales

The first scales designed to rate injury severity were developed in 1943 for the purpose of studying airplane crashes, (Committee on Medical Aspects of Automotive Safety, 1971). In 1969 the Abbreviated Injury Scale,(AIS), (see Appendix A) was introduced and then further refined in 1978-1979, resulting in the publication of the AIS-80 which has been used consistently since this time to categorize the severity of injury from many different sources, such as auto accidents and plane crashes (Kramer, Barancik, & Thode, 1990). The literature supports the use of the AIS, (see Appendix A), as a tool for easy documentation of injury severity, and recognizes the possibility of inconsistencies because injury categorization is still left up to professional judgment. The use of injury scaling in organized medicine was initiated in 1966 through the efforts of the American Medical Association and its Committee of the Medical Aspects of Automotive Safety. The AIS is a numerical scale developed to rate the severity of injuries and not a system used for the coding of fatalities. In addition, it does not propose to assess the combined effect of multiple injuries sustained by any individual (Petrucelli, States, & Hames, 1991). Baker (1974) quotes the authors of the AIS as cautioning against adding or averaging the AIS ratings, claiming that "the quantitative relationship of the AIS codes is not known and is almost certainly nonlinear" (Baker, O'Neill, Haddon, & Long, 1974).

Further review of the literature supports this observation and shows that the AIS is not an additive progression scale. The original 1971 publication of the AIS was revised in 1978-1979, which led to the development of the AIS-80 in 1980. The revisions made in the AIS resulted in very few changes in the injury codes but rather clarified injury descriptions and strengthened the overall system. Currently, the AIS is used by large numbers of crash investigators all over the world, (Petrucelli, States, & Hames, 1981), and has been adopted as the official tool used by all U.S. federally funded crash investigation teams (MacKenzie, Shapiro, Moody, & Smith, 1984). In studies where the severity of injury is rated, the AIS has provided a flexible, logical framework by which categorization is done quickly and easily (see Appendix A). The categories of AIS framework are simply laid out, but do require the judgment of professionals to place the victim in a particular category. Thus, the degree to which morbidity and mortality are related has continued to remain conjectural in spite of the medical ease of the scale itself (Baker, O'Neill, Haddon, & Long, 1974). The studies that did use the AIS the injury category and injury description were well defined and readily understood, making reader comparisons easier, (Baker, O'Neill, Haddon, & Long, 1974).

Most studies discussing bicycle-related injuries do not specifically discuss rating injury severity, making it difficult to determine how serious the injuries were.

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Larson, (1995) did examine injury severity through the use of the AIS. By using a Maximum AIS (MAIS), which is the highest AIS-score in all body regions, the severity and site of injuries sustained correlated with findings in other bicycle studies. This study showed that the AIS-system as a useful tool to describe injuries, which generally tend to be less severe following bicycle accidents (Larson, 1995).

## Definition of Terms

1. Bicycle - a two-wheeled vehicle powered by pedaling.
2. Adult rider - a male or female over the age of 21 years.
3. Pediatric rider - a male or female 21 years of age or younger.
4. Location of injuries - (see Figure 3).
    A. Head - area of skull that is normally covered by scalp hair.
    B. Face - area of skull not normally covered by scalp hair, to involve eyes, ears, nose, mouth, chin, forehead and cheeks.
    C. Neck - area from angle of mandible to the junction of neck and chest.
    D. Shoulder - area involving glenohumeral joint and clavicle.
    E. Upper extremity - defined as being distal to glenohumeral joint to tips of fingers.
    F. Chest - inferior to clavicle to inferior border of ribs.

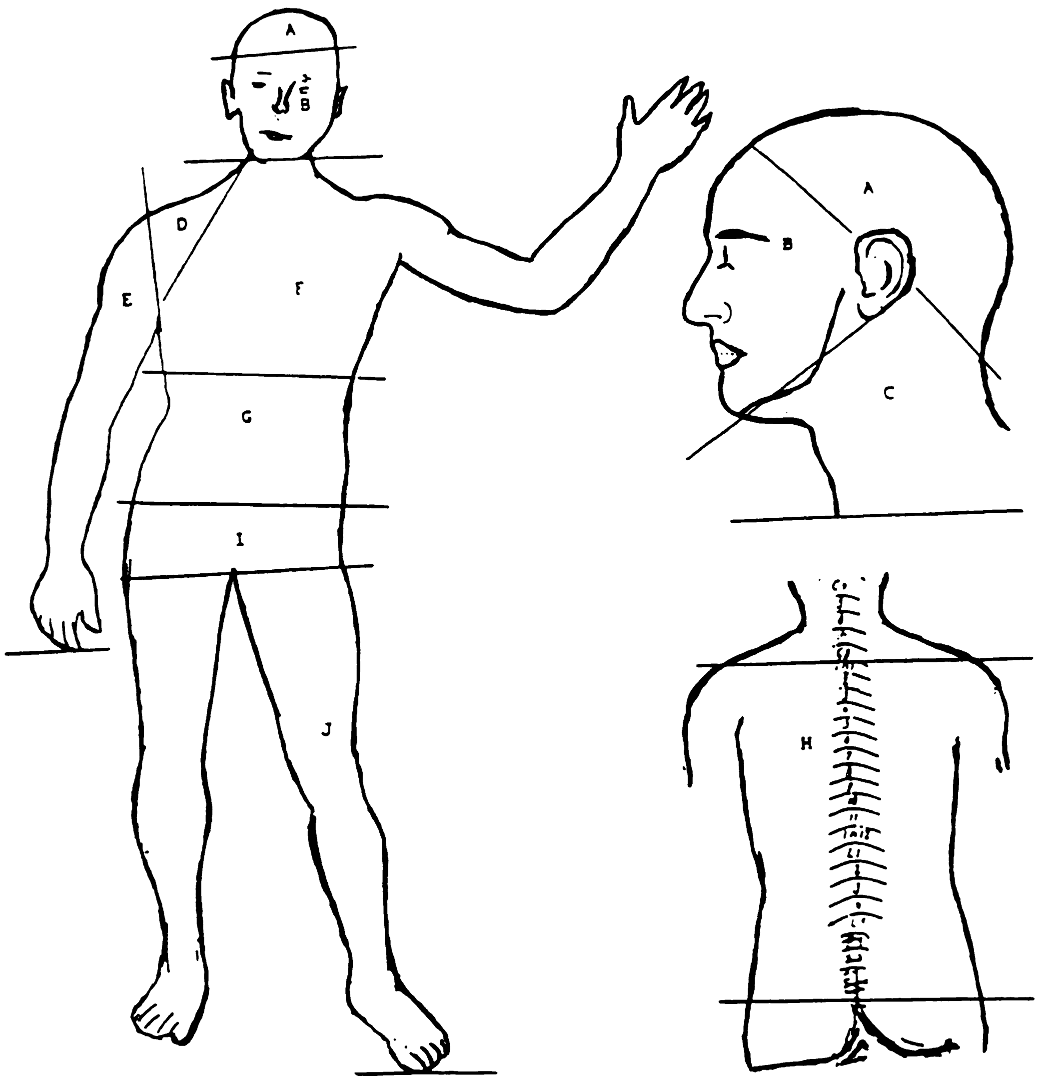


Figure 3.

Anatomical Schemata for Injury Location

G. Abdomen - inferior margins of ribs to iliac crest and inguinal ligament, to include internal injuries.

H. Back - T1 through tip of sacrum.

I. Groin - genital area from inguinal ligament to involve genitalia.

J. Lower extremity - extends from hip to tips of toes.

5. Types of injuries documented in police or health clinic records, including:

I Concussion - closed head injury - a transient loss of consciousness occurring immediately following a non-penetrating blunt impact to the head.

II Fracture - a complete or incomplete break in the continuity of a bone.

III Laceration - a rough, jagged tear of the skin tissue.

IV Contusion - an injury to the subsurface tissue without the skin being broken.

V Abrasion - scraping away of a surface by friction.

VI Subdural - collection of blood in the subdural space.

VII Epistaxis - bloody nose.

VIII Strain - muscle damage secondary to trauma.

IX Dislocation - displacement of bone from an articulating joint.

X Sprain - injury to a ligament or tendon around a joint.

XI Separation - displacement of bone from bone at ligamentous attachments at non-articulating joints.

XII No injury - accidents occurring in which the rider received no injury.

XIII Minor cuts and scrapes - injuries occurring in which no specific body parts are listed in reports.

6. Injury severity will be based on a modification of the Abbreviated Injury Scale as reported in police records, from 1 to 5, with 1 being the least serious and 5 being fatal (see Appendix B).
7. Victim - an individual injured in a bicycling accident, including the driver of the bicycle, bicycle passenger, or a pedestrian run into by a bicyclist.
8. Incident type - bicycle-bicycle, bicycle-horse, bicycle-pedestrian, or bicycle alone, or other.
9. Accident and incident will be used inter-changeably in this study.

## Methodology

Mackinac Island is a popular tourist destination located off the coast of Northern Michigan between Lake Huron and Lake Michigan (see Figure 4). Mackinac Island has 500-600 permanent residents with an estimated annual tourist rate well over 1,000,000 visitors per year. The majority of

Figure 4.

Mackinac Island Map

individuals come to Mackinac Island between the months of May and October. It is estimated that during this time Mackinac Island receives up to 10,000 visitors per day. An 8-mile road circling the entire island and multiple paved trails travel throughout the interior of the hilly island. One of the unique aspects of this vacation spot is the ambiance created by the horse-drawn carriages and bicycles used as the major means of transportation by visitors and residents alike. There are 3 motorized vehicles on the island, a police car, an ambulance, and a fire truck. Travel to Mackinac Island is mainly by ferry from the main coast of Michigan, though there is an island airstrip.

Bicycles provide the major means of transportation to sight-seers and help to create an unusual environment in which to study the prevalence of bicycle-related injuries. Visitors may choose to bring their own bicycle or rent one on the island. It has been estimated by the Mackinac Island Chamber of Commerce that over 150,000 bicycles are rented at the 4 bicycle rental shops each year, not including the rental of bikes from the 36 places of lodging. This unique environment poses its own special set of circumstances that may act as causative factors for bicycle mishaps including:

1. Often shared routes among horse transports, pedestrians, and bicyclists;
2. A large number of bicyclists sharing the roadway with varying degrees of expertise riding rental bikes unfamiliar to them;

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3. Bicycles by themselves offer nothing in the way of protection to the rider;
4. Many bicyclists often come to Mackinac Island unprepared for bicycling, including having no safety gear and inappropriate clothing;
5. Traveling down hills while viewing the scenery rather than the road;
6. High rates of speed attained by the bicyclists may be quite significant and lead to severe injury in a crash; and
7. Rough pavement or gravel road surfaces, and weather conditions may create a setting in which a mishap can occur.

Bicycle helmet usage is very low and, in the majority of instances, bicycle helmets are not readily available to the riders when they rent their bike.

Bicycle riders on Mackinac Island vary greatly in age and skill and a large number in not wearing a bicycle helmet while riding on the island. Mackinac's isolated setting without the presence of automobiles and high bicycle usage offers a unique opportunity in which to study bicycle injury patterns in pediatric and adult riders. However, the very uniqueness of the setting may make it difficult to generalize the results to other communities.

The purpose of this study is to determine the number of bicycle crashes, location of accidents on the island, types and severity of injuries reported and medical care given with the intention of comparing these results between the pediatric and adult bicycle-riding population. This retrospective study will examine all bicycle-related accident data from police and health clinic records on Mackinac Island from 1994 through 1996. Major components of this study are to include the age of the victim, an adult being over 21 years of age and a pediatric victim 21 years of age or younger, injury occurrence and documented severity of injury, as well as crash location on the island.

## Study Design

For this study a retrospective record review of all police records of bicycle crashes occurring on Mackinac Island during the years 1994-1996 was done.

## Population and Sample

All bicycle accidents reported to the police and health department on Mackinac Island were examined, a total of 290 cases from 1994 through 1996. Included in this study will be anyone who had reported an accident, for example, a parent reporting an accident involving a child, to the police department or was treated at the health clinic for injuries resulting from a bicycle-related accident. This study is one of a three part study undertaken with Dr. Mary Hughes, Department of Internal and Emergency Medicine in the College of Osteopathic Medicine at Michigan State University. The author of this thesis was involved in data collection, entry and analysis. A distinction between individuals in the residential and tourist population was not made. Therefore, anyone involved in a bicycle-related crash that occurred on Mackinac Island from 1994 through 1996 was included in this study. Although on the surface the overall estimated incidence of accidents may seem insignificant, less than .1 percent (290 per approximately 450,000 rentals), these numbers may be misleading. The average rental time is one hour and therefore this rate (<.1 percent) can not be compared to other studies involving cyclists who ride on a regular basis many hours a year. Permission to view the police and health clinic records was previously obtained by Dr. Hughes from the Mackinac Island Police Department and the Mackinac Island Medical Clinic.

## Human Subjects Approval

Human subjects' approval was granted for this project by Michigan State University and Sparrow Hospital. No accident victim is individually identified in the study results. All data collection sheets are maintained in the personal possession of Dr. Hughes and are not available for public use.

## Instruments

The Abbreviated Injury Scale (1980) was modified for ease of use during this study and employed in conjunction with the injury code classification developed and used by the Mackinac Island Police Department (Appendix D). The data will reflect only injuries in which a police report was filed. All cycle accident victims who present to the island clinic for treatment automatically have a police report generated. Those individuals who felt their accident was serious enough to report to the police also result in a police report being generated. Not all minor accidents are reported to the police or require medical attention, and therefore the crash totals do not necessarily indicate all accidents occurring on Mackinac Island during this period of time.

Two instruments were used to measure and organize data for this study. The first was a modification of the Mackinac Island Injury Survey (Appendix B) developed by Dr. Hughes to obtain and organize data relevant to the number of tourists, bicyclists, and information associated with a bicycle accident on the island and bicycle helmet use. The Mackinac Island Injury Survey was specifically developed for this study and has not been used in other studies to date. For the purposes of this project this survey was modified for ease of handling to include only information that was necessary to aid in injury comparison between the pediatric and adult bicycle population. This tool was titled the Modified Mackinac Island Injury Survey (Appendix C). The data collected from police and health clinic records was examined and placed into the appropriate category.

The categories in the Modified Mackinac Island Injury Survey include date of incident, whether the accident occurred on a weekday or weekend, island site of accident, time when the incident occurred, type of accident, anatomical site of injury and injury severity. Further information regarding the age and gender of the victims, along with a cross-check of files to see if the accident victim who did not obtain medical care at the time of incident reported injury to the health clinic within 24 hours of the accident. To aid in the categorization of injury severity listed in the records, a space was made available to document a brief description of injuries, this information was be used by medical personnel to determine the most appropriate coding for injury severity.

The second tool used in this study was a modification of the Abbreviated Injury Scale - 6 severity Code (Appendix E). This tool titled the Modified Abbreviated Injury Scale (Appendix D), was modified to correlate injury severity data from the Mackinac Island Police Department incident sheets and the AIS scale. Included are injuries from these categories that required individuals to be transported to mainland hospitals for treatment. The severity code used by the Mackinac Island Police Department follows the AIS categories in reverse and was adhered to in this study. The injuries are ranked from 1 through 5, 1 - fatal to 5 - no injury.

Data Collection Procedures

The authors went to the Mackinac Island Police Department and reviewed all records related to bicycle injury. The records were made available on the premises from the police department. Data was transferred to the Mackinac Island Injury Survey. Where injuries were not noted, the survey was then taken to the Mackinac Island Medical Clinic and a search was made for the victim in their files. If found, the injuries were then noted on the survey. Charts remained on the premises of the clinic at all times. Data was then coded and entered into the EpiInfo Statistical Program and transferred to SPSS program for data analysis.

For the purpose of this study, "adults" will be any victim greater than the age of 21 years of age and "pediatric" will be any victim 21 years of age or less, as defined by the American Academy of Pediatrics. The determination of age groups was established by Dr. Hughes and the College of Osteopathic Medicine at Michigan State University. Totals will be generated to indicate adult and pediatric victims for the study period. Mean ages and ranges will be calculated. Gender as a relative percent of total in age group will also be calculated.

## Results

This study examined the records of all accident victims located at the Mackinac Island Police Department and Health Clinic (n=290 with 1 undocumented case) from 1994 through 1996.

### Research Question 1

In answer to the first research question, the results indicate a smaller number of pediatric victims, 43.1 percent (n=125) compared to 56.6 percent (n=164) adults. The mean age of a pediatric victim was 12.2 years with a standard deviation of 6.44. The mean age of the adult victim was 41.2 years with a standard deviation of 15.9 years. The mean age of all victims was 28.7 years with a standard deviation of 18.94 years (range 1 - 88 years) (See Table 1).

A relative percentage obtained by cross tabulation with a Pearson chi-square was performed on the totals of accident victims who did or did not seek medical care at the island health clinic. Results show a significantly lower proportion of children (72.8 percent) than adults (85.5 percent), $p < .045$, seeking medical care at the clinic after their reported bicycle accident (See Table 2).

In each age group, Emergency Medical Service (EMS) transport to the clinic and transport off the island for

Table 1.

Means by Age Group

Age of Person

| | | |
|---|---|---|
| 1.0 | Mean<br>N<br>Standard Deviation | 12.2000<br>125<br>6.4458 |
| 2.0 | Mean<br>N<br>Standard Deviation | 41.4268<br>164<br>15.1908 |
| Total | Mean<br>N<br>Standard Deviation | 28.7855<br>289<br>18.9442 |
| 1=Peds 21 years and less | | |
| 2=Adults 22 years and greater | | |

Table 2.

Percentage of Victims per Age Group using Clinic Services

Pediatric vs. Adults Clinic Crosstabulation

| | | | Clinic | | |
|---|---|---|---|---|---|
| | | | No | Yes | Total |
| Pediatric vs. Adults | Age less than 22 | Count | 34 | 91 | 125 |
| | | % of age group | 27.2% | 72.8% | 100.0% |
| | | % within Clinic | 56.7% | 39.9% | 43.3% |
| | | % of Total | 11.8% | 31.5% | 43.3% |
| | Age older than 21 | Count | 26 | 137 | 164 |
| | | % of age group | 15.9% | 83.5% | 100.0% |
| | | % within Clinic | 43.3% | 60.1% | 56.7% |
| | | % of Total | 9.0% | 47.4% | 56.7% |
| Total | | Count | 60 | 228 | 289 |
| | | % of age group | 20.8% | 78.9% | 100.0% |
| | | % within Clinic | 100.0% | 100.0% | 100.0% |
| | | % of Total | 20.8% | 78.9% | 100.0% |

Chi-Square Test

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 6.197 | 2 | .045 |
| N of Valid Cases | 289 | | |

care. Results show that a higher percentage of adult accident victims used EMS services, 58.3 percent, (95 of 163 injured), compared with 44 percent of pediatric victims, (55 of 125 injured). Results of a Pearson's Chi Square revealed p of 0.016 indicating that there was a statistically significant difference in the percentages between pediatric and adult usage of EMS services. When reviewing the percentages of victims per age group that were transported off the island for care, results indicated that there was a greater percent of adult victims, 4.4 percent, (7 of 161 injured with 2 cases undocumented) transported off the island compared to 2.4 percent of pediatric victims, (3 of 125 injured). Because of the small number of victims a Fisher's exact was done to test for the significance of these percentages. These results revealed a p value of 0.375 indicating that the difference between these age groups with respect to being transported off the island was not statistically significant (see Table 3).

Research Question 2

In answer to the second research question concerning where most accidents occur, a map indicating location of incidents was developed to depict the occurrence in each population separately (See Figures 5 and 6). Each dot on the map represents one accident. The map relating to pediatric accident location (Figure 5) indicates a high

Table 3.

Percentage EMS and Off Island Transport by Age Group

| | XEMS | | XEMS | | XOFFIS | | XOFFIS | |
|---|---|---|---|---|---|---|---|---|
| | Count | % | Count | % | Count | % | Count | % |
| 1 | 55 | 44.0 | 95 | 58.3 | 3 | 2.4 | 7 | 4.4 |
| 2 | 70 | 56.0 | 68 | 41.7 | 121 | 97.6 | 153 | 95.6% |
| Total | 125 | 100.0 | 163 | 100.0 | 124 | 100.0 | 160 | 100.0 |

1=pediatric 2=adults


Figure 5

Pediatric Incident Location

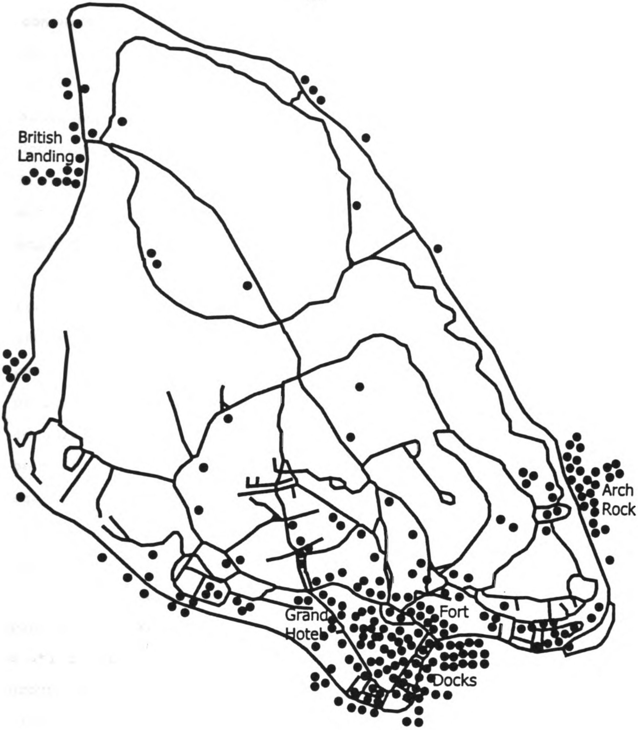


Figure 6

Adult Incident Location

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concentration of incidents around the docks, which is the downtown region. To a lesser degree a cluster of accidents is seen at Arch Rock and British Landing. Likewise in the adult population a large cluster of accidents is seen at the dock region (Figure 6) followed by Arch Rock and finally British Landing. No distinctive geographical patterns specific toe each age group is discernible.

Research Question 3

A cross tabulation of days of week when accident occurred with age group (pediatric vs. adult) was done for 289 (99.7 percent) of a total 290 cases over 3 years being reported, see Table 4. Results show that for the pediatric population, the lowest number of incidents (8.8 percent) occurred on Sunday, while the highest percentage, (18.4 percent) Wednesday and Thursday (See Table 5). In the adult age group the lowest percentage of incidents was on Thursday (9.8 percent), with Saturday having the highest number of incidents (33) (See Table 6).

A chi-square frequency test was done on both populations respectively though these results did not reach statistical significance. Results for the pediatric age group revealed a chi-square value of 6.432 and a p value of .377 (Table 5). Likewise for the adult group a chi-square value of 17.366 with a p value of .054 was obtained (table 6).

Table

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Table 4.

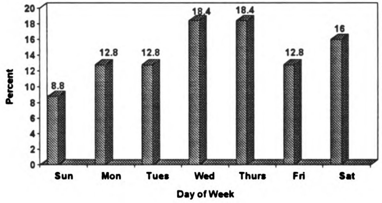
Percentage of Accidents by Day of Week in each Age Group

Pediatric vs. Adult Day of Week Crosstabulation

| | | Day of Week | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Sun | Mon | Tues | Wed | Thurs | Fri | Sat |
| Pediatric vs. Adult | Count | 11 | 16 | 16 | 23 | 23 | 16 | 20 |
| Age less than 22 | % within Pediatric vs. Adult | 8.8 | 12.8 | 12.8 | 18.4 | 18.4 | 12.8 | 16.0 |
| Age Older than 21 | Count | 31 | 17 | 18 | 27 | 16 | 22 | 33 |
| | % within Pediatric vs. Adult | 18.9 | 10.4 | 11.0 | 16.5 | 9.8 | 13.4 | 20.0 |
| Total | Count | 42 | 33 | 34 | 50 | 39 | 38 | 53 |
| | % within Pediatric vs. Adult | 14.5 | 11.4 | 11.8 | 17.3 | 13.5 | 13.1 | 18.4 |

Table 5.

Pediatric Percentage of Accidents by Day of Week

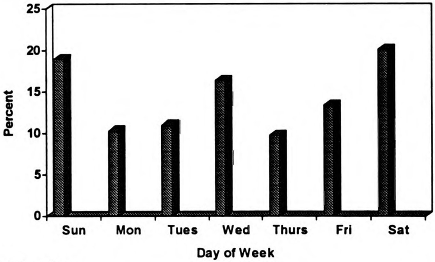



Test Statistics

| | Day of Week |
|---|---|
| Chi-Square | 6.432 |
| df | 6 |
| Asymp. Sig. | .377 |

Table 6.

Adult Percentage of Accidents by Day of Week




Test Statistics

| | Day of Week |
|---|---|
| Chi-Square | 12.366 |
| df | 6 |
| Asymp. Sig. | .054 |

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Research Question 4

Results for accidents by time of day indicated that the highest rate per hour of accidents occurred between the hours of 12 noon and 8 pm for both age groups. The pediatric group reported a rate of 11.38 incidents per hour, whereas the adult group reported 11.62 incidents per hour. A Chi-Square test on each group revealed significant results with a p value of .000 (See Tables 7, 8 and 9). This observed difference in accident rates among both the pediatric and adult populations may well be due to sampling chance.

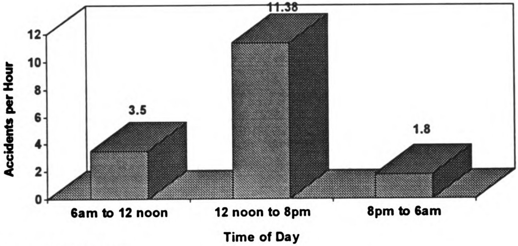
Research Question 5

Results for relative frequency and anatomical location of injury reveal totals of 150 and 255 injuries respectively documented in the pediatric and adult populations. Some victims sustained more than one injury during an accident thus totals reported were greater than the number of accident reports.

Injury totals documented in the pediatric and adult age groups were not significantly different from each other. The highest incidence of injury location occurred in the upper extremity for both groups, 22.2 percent for the pediatric group and 24.5 percent for the adult respectively. However, it is noted that when combining head and face injuries the percentage for adults is slightly higher (25.7 percent verses 24.5 percent) than those occurring in the upper extremity. For the pediatric age group the combined

Table 7.

Pediatric Three Year Accident Density by Time of Day

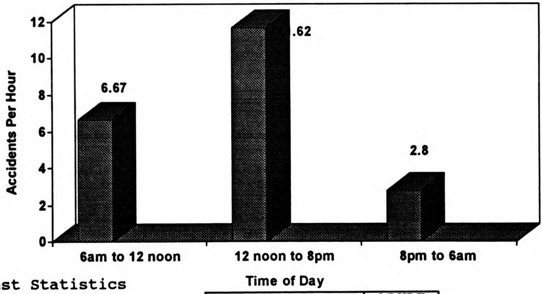



Test Statistics

| | PEDS |
|---|---|
| Chi-Square | 95.678 |
| df | 2 |
| Asymp. Sig. | .000 |

Table 8.

Adult Three Year Accident Density by Time of Day




Test Statistics

| | ADULT |
|---|---|
| Chi-Square | 51.607 |
| df | 2 |
| Asymp. Sig. | .000 |

Table 9.

Percentage of Accidents by Time of Day and Age Group

Time - Population Crosstabulation

| | | | Population | | |
|---|---|---|---|---|---|
| | | | Peds | Adults | Total |
| Time | 6am-12noon | Count | 21 | 40 | 61 |
| | | % within TIME | 34.4 | 65.6 | 100.0 |
| | | % within POP | 17.1 | 24.8 | 21.5 |
| | 12noon-8pm | Count | 91 | 93 | 184 |
| | | % within TIME | 49.5 | 50.5 | 100.0 |
| | | % within POP | 74.0 | 57.8 | 64.8 |
| | 8pm-6am | Count | 11 | 28 | 39 |
| | | % within TIME | 28.2 | 71.8 | 100.0 |
| | | % within POP | 8.9 | 17.4 | 13.7 |
| Total | | Count | 123 | 161 | 284 |
| | | % within TIME | 43.3 | 56.7 | 100.0 |
| | | %within POP | 100.0 | 100.0 | 100.0 |

head and face rates were higher than upper extremity rates (28.1 percent verses 22.2 percent). A smaller difference was noted between age groups with regards to the least frequent anatomical location of the injury. In the pediatric group, the abdomen sustained the least percentage of injuries (0 percent), whereas in the adult population the least percentage was found to be seen equally in the neck, groin, and abdomen (.4 percent). The percentage of minor injuries reported were almost identical, 8.5 percent and 8.3 percent respectively. Injuries listed as unknown were agai

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again similar with 10 percent being reported in the pediatric group and 10.8 percent reported in the adult group (See Figure 7). Again, all observed differences were not statistically significant, indicating the essential similarity in injury patterns among pediatric and adult riders.

Research Question 6

The sixth research question is concerned with injury severity. Relative frequency for both age groups was done, rating injuries from 1 to 5, 1 = fatal and 5 = no injury. Of the 125 pediatric accidents reported, 114 had documented injury severity. In the adult group, 164 of 165 cases had this information documented. Similar injury severity patterns were seen in both age groups, with category 3 injuries being the most frequently reported. Only the adult group reported a category 1, fatal injury, with 1 case or .6 percent of adult injuries. The adult group also reported a slightly higher percentage of category 2 injuries, rated as incapacitating, 27.4 percent compared to 21.9 percent in the pediatric population. Category 3 injuries, listed as non-incapacitating, showed a higher percentage of pediatric injuries (64.9 percent) when compared to the adult group (59.7 percent). Category 4, minor injuries, listed similar results with 6.1 percent of pediatric injuries and 4.8 percent of adult. The final category, 5, no injury, held almost identical results with 7 percent of pediatric

Anatomic Site

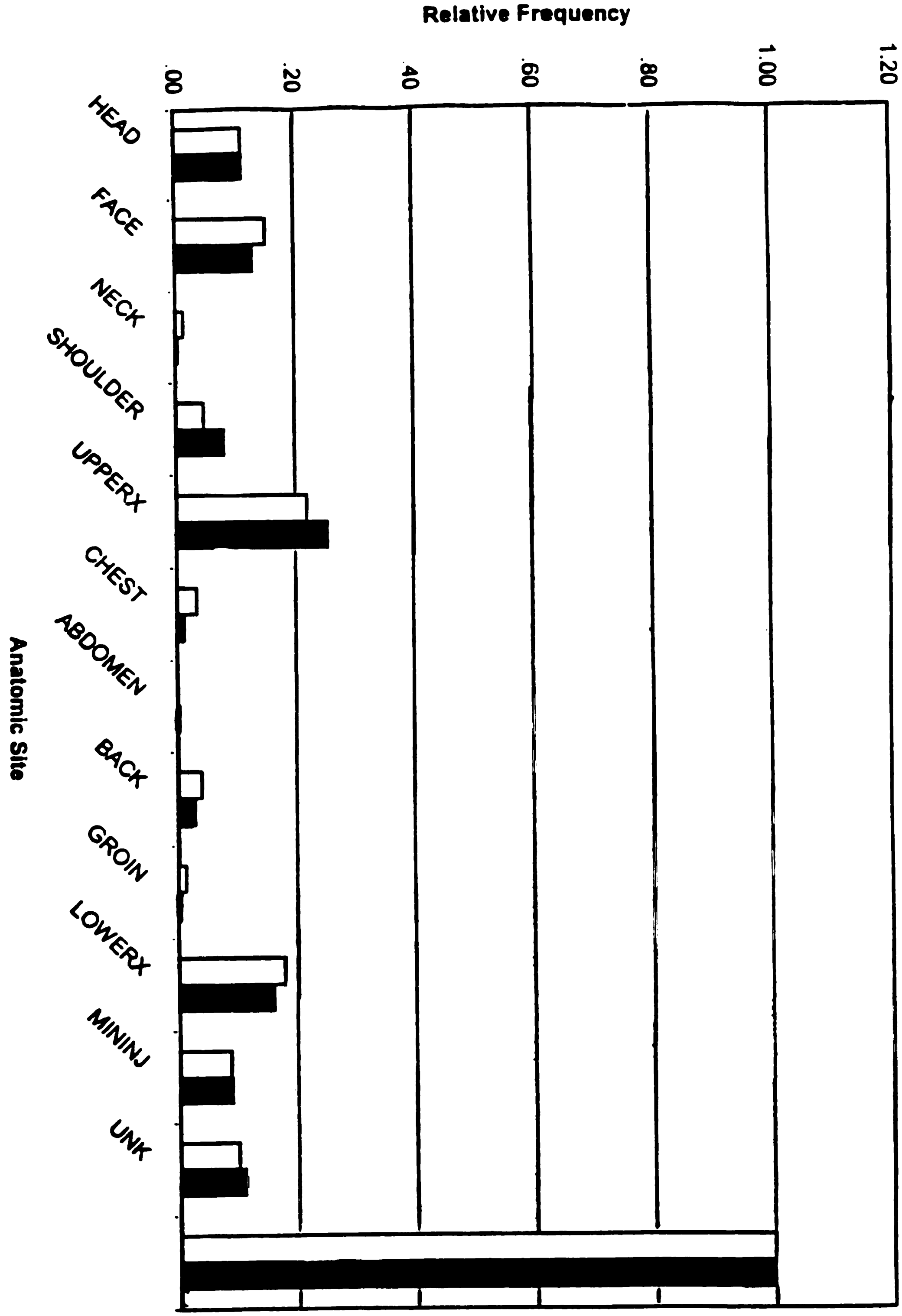


Figure 7

Relative Frequencies by Anatomical Site by Age Group

□ Pediatrics
■ Adults

accident victims and 7.3 percent of adult crash victims (See Figure 8).

A Pearson's Chi Square test for significance revealed, for category 2, a p value of 0.298 (Chi Square = 1.08), category 3, a p value of 0.384, (Chi Square = .76), category 4, a p value of 0.734, (Chi Square = .11), and category 5 a p value of 0.924 (Chi Square = .01). For all of the injury categories there is no statistical difference between the pediatric and adult age groups. When looking at all categories together, the overall Chi Square was 2.0 with 4 degrees of freedom and a p value of 0.7354. A crosstabulation was done comparing categories 1 and 2 between the pediatric and adult group as well as categories 3, 4, and 5. In the sample the results showed there to be an odds ration of 1.388, with a 95 percent confidence interval of .793 - 2.428, indicating that there was 38.8 percent higher odds of severe injury in adults. Though these results appear to be significant a p value of .247 was reported indicating that there was no significance (see Table 10.

### Assumptions

This study assumes that police and health care workers using the injury severity scale have a consistent understanding of what the categories 1 - 5 encompass. The data entered by police and health clinic workers on their reports is treated as accurate assessments of the health status of the victims with the understanding that the

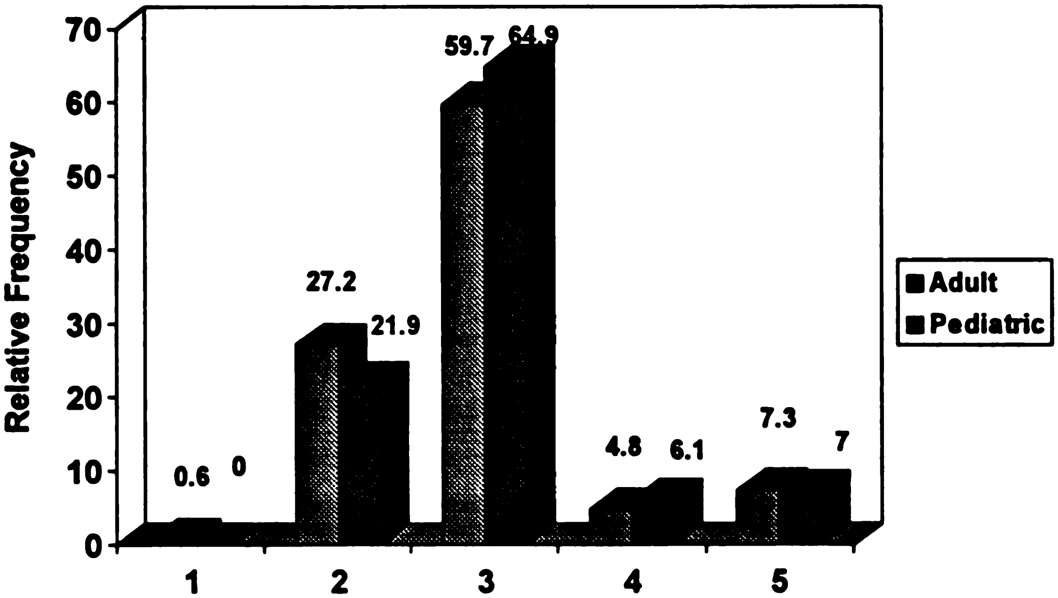


Figure 8. Relative Frequency of Pediatric and Adult Injury Severity

Table 10.

Pediatric and Adult Injury Severity

Crosstabulation

| | | PEDS | ADULTS | TOTAL |
|---|---|---|---|---|
| Severity Code 3, 4, and 5 | Count<br>Percentage | 89<br>78.1 | 118<br>72.0 | 207<br>74.5 |
| Severity Code 1 and 2 | Count<br>Percentage | 25<br>21.9 | 46<br>28.0 | 71<br>25.5 |
| Total | Count | 114 | 164 | 278 |
| Odds Ratio | 1.3 | | | |
| p Value | .244 | | | |
| 95% CI | .793-2.428 | | | |

subjective nature of rating injuries can be encompassed in the injury severity scale.

Though the AIS was developed in 1960 -1970, and further adapted in 1979, because of its extensive use throughout the world it is assumed to be able to rate the severity of injury accurately.

## Discussion

Results showed that a greater number of accidents reported were in the adult age group and that adults sought medical care at the island health clinic in greater percentages as well. Furthermore, a larger percentages of adult accident victims used EMS transport to the clinic compared to their younger counterparts. Adults also required transport off the island in larger numbers, although there doesn't appear to be a marked difference in injury severity among the adult population. Multiple factors may be considered when looking at the difference between these two populations, including difference in rider experience, possible alcohol or medication use, and adults generally weigh more.

As was expected, there were a greater number of incidents occurring in areas where there was the most congestion, around the docks, Fort, and Grand Hotel. Both the British Landing and Arch Rock provided the rider with challenging terrain and an interesting view and this may explain why the accident rate is greater in these areas. The largest percentage of accidents happened between 12 noon and 8 pm as anticipated, with the largest percentage seen in the pediatric group, 74 percent, compared with 57 percent in adults. Most visitors do not spend the night on Mackinac Island therefore boat arrival and departure times may be the reason why the majority of accidents with children occur during this time.

When reviewing results for day of week, adults tended to have more accidents on weekends and on Wednesday, whereas the pediatric age group had the highest incident rate during the middle of the week. Because of the lack of knowledge regarding the population base, it is difficult to relate occurrence to actual numbers of adult or pediatric visitors on a particular day.

The anatomical site of injury revealed the greatest percentage of injuries sustained in the upper extremity, 22 percent for the pediatric group and 25.5 for the adults. The second most prevalent injury site was the face with 15.3 percent and 13.2 percent for pediatric and adult bicyclists respectively. These results are consistent with results from other studies.

In analyzing injury severity (see table 9), the results showed adults sustained a greater percentage of injury in the most serious categories, 1 and 2, though not significant, with the percent of pediatric injuries surpassing them in category 3. There was approximately the same percentage 7 and 7.3 percent respectively in the no injury category.

When looking at the results from an overall perspective, trends begin to show. There is a tendency for there to be a greater number of injuries of adults across the board, but this study is unable to answer why. This data does not indicate whether there are simply more adults than children biking on the island and thus making the number of injuries higher for the adults. This study did show, however, that there was a significant health risk to the tourist population, and these results could be used as an impetus for developing safety programs that would protect both visitor and resident.

Limitations

The study is limited by the lack of thorough and consistent documentation of accidents. In the majority of instances, specific locations were documented but not 100 percent of the time. Other mitigating factors such as weather conditions, road conditions, victims view of why the accident occurred, stated use of alcohol, incidence of helmet use, and experience of the rider all may have played a role in determining the accuracy of the results. The documentation of injury severity may have been affected by the personal interpretation of the police or health officials reporting the accident. The data only reflects accidents serious enough to be reported to the police or those that required treatment at the health clinic. The data does not include all accidents that may have occurred during the study period. The lack of information on the

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population base with regards to the number of adult and pediatric visitors who bicycled on Mackinac Island during the period of observation limited the ability to make comparison between age groups. The uniqueness of Mackinac Island does provide a good environment in which to study bicycle injuries unaffected by automobiles. However, this same uniqueness may make it difficult to generalize the results to other resort communities.

The AIS, though extensively used by itself, has not been well documented as an effective tool to be adapted to other injury scales. Though the injury rating used by the Mackinac Island Police Department is based on the AIS, it specifically has not been tested for reliability and validity.

## Future Research

Further research is needed in other resort communities to see if the results obtained in this study persist in other areas. This research should also attempt to include more information on the population base that could facilitate age group comparisons. The main focus of this research project was to look at injury occurrence and to determine if there was a safety concern on Mackinac Island. This study did not attempt to answer questions as to why. In order to effectively develop programs that will promote safety, these questions need to be answered. Future research should be aimed at developing an understanding of the causes of injury and then establishing safety protocols that reduce the occurrence and severity of injury that can be applied to other tourist communities.

Implications

For the purpose of this study, Pender's HPM was used with regards to implications for the Advanced Practice Nurse (APN) and the development of safety interventions that promote health behaviors, see Figure 2. Understanding the incidence of injury and the source and mechanism of action provides effective tools for the health care professional to actively develop and promote health awareness programs for injury prevention on individual and community levels. Though all individuals who encounter the safety message will not be sufficiently motivated to adopt health- behavior, everyone directly or indirectly will bear the cost in injuries that could have been prevented (Kellerman & Martinez, 1996). There is no guarantee that simply adopting healthy behaviors will eliminate the risk of injury. Several strategies for the prevention of injury can be developed after first defining the problem and then identifying causes and risk factors (Kellerman & Martinez, 1996). Categorizing an identifiable injury in relation to its severity is essential in order to understand associated morbidity and mortality rates (Baker, O'Neill, Haddon, & Long, 1974).

The data and information gathered, relating to rider demographics, health care services and accident factors develop into external cues which can lead directly to positive health-promoting behaviors or be used as cognitive perceptual factors for the basis of developing interventions. The perceived benefits can be enhanced through safe rider practices, and the development of educational programs for the bike rental shops with regard to the magnitude of the problem as well as means of making positive changes related to bicycle safety. Awareness of the perceived barriers to these interventions, such as lack of knowledge regarding risk and proper use of safety equipment, as well as accessibility, is necessary in order to establish programs or interventions that will indeed be used by the community and the individual bike rider on Mackinac Island. Undocumented data, like helmet usage, can be a focus of the APN in assisting the police and health departments to improve information gathering regarding injury patterns. Improving the forms that are used to report accidents can be a useful tool in the evaluation of safety programs instituted.

Injury cause emerges as an important factor when determining possibility of prevention. Many studies incorporated causation into their projects and discovered significant factors that repeatedly presented. Though most accidents do not involve motor vehicles, most fatalities do, and as a result, a great deal of information can be found. Studies consistently found the cyclists were generally at fault due to their failure to obey traffic laws (Noakes, 1995). Few studies comparing injury causation in the pediatric and adult population were found, but in separate studies certain trends emerge. The lack of skill, (Noakes, 1995) followed by environmental conditions, (Gilbert & McCarthy, 1994) were the most prevalent reasons, and though little research has been done in the tourist community, it seems as though these trends may well continue (Carey & Aitken, 1996).

By understanding the benefits as well as the barriers to health promotion the APN is provided with an excellent opportunity to act as an educator and advocate for safety on the individual and community level. The APN can assist the community in understanding the magnitude of the current health risks and develop programs that will assist them in providing a safer environment for their guests. The APN can assist the community in exploring and developing appropriate strategies which promote safety of the individual rider. Through the use of bulletins attached to current advertising brochures the visitor can be made aware in advance of coming to Mackinac Island of appropriate action to take in order to promote their own safety, such as bringing their own bicycle helmets if they do not wish to rent one on the island. Assisting the bike rental shops in obtaining proper sizes and numbers of helmets necessary to meet the needs of the riders along with teaching the employees proper equipment fit might be a means of encouraging business participation in bicycle safety. Once on the island the use of signs posted at strategic spots along pathways depicting and encouraging correct helmet use along with safe rider practices could further enhance the safety message. These signs could further warn the visitor of changes in terrain as well as dangerous intersections can also be of great benefit in promoting safety.

Through the role as evaluator the APN can continue to assist the community on Mackinac Island in identifying what is and is not effective in terms of safety promotion and give further voice to the perceived susceptibility of already identifiable high risk situations. Evaluating the current means of reporting and tracking accidents on the island through police and health clinic forms may be one means of achieving this goal.

## Conclusion

It is hoped that this study has helped define a safety problem on Mackinac Island as it relates to the safety of its bicycle riders. Safety issues are one of the many concerns that a host community has in a highly visited tourist destination. The information gathered from this study will be used to assist the community of Mackinac Island in developing safety programs that will reduce injury from bicycle accidents and help improve the quality of information obtained when an accident occurs.

It is the responsibility of all members of a community to not only provide for the safety of its own members, but also its guests. By continually evaluating risk potential and through the development and promotion of successful safety programs the most memorable event may be the one that never occurred, a preventable injury.

# LIST OF REFERENCES

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# APPENDIX A

# ABBREVIATED INJURY SCALE

## ABBREVIATED INJURY SCALE

| Severity Code | Severity Category/Injury Description | Police Code |
|---|---|---|
| 0 | No Injury | O or D |
| 1 | Minor<br>General<br>Aches all over<br>Minor lacerations, contusions, and abrasions (first aid - simple closure)<br>All 1st degree or small 2nd or small 3rd degree burns<br>Head and Neck<br>Cerebral injury with headache; dizziness; no loss of consciousness<br>"Whiplash" complaint with no anatomical or radiological evidence<br>Abrasions and contusions of ocular apparatus (lids, conjunctiva, cornea, uveal injuries); vitreous or retinal hemorrhage<br>Fracture and dislocation of teeth<br>Chest<br>Muscle ache or chest wall stiffness<br>Abdominal<br>Muscle ache; seat belt abrasions; etc.<br>Extremities<br>Minor sprains & fractures and/or dislocation of digits | C |

| Severity Code | Severity Category/Injury Description | Police Code |
|---|---|---|
| 2 | **Moderate**<br>**General**<br>Extensive contusions; abrasions; large lacerations; avulsions (less than 3" wide)<br>10%-20% body surface 2nd or 3rd burns<br>**Head and Neck**<br>Cerebral injury with or without skull fracture, less than 15 minutes unconsciousness no post-traumatic amnesia<br>Undisplaced skull or facial bone fractures or compound fracture of nose<br>Lacerations of the eye and appendages; retinal detachment<br>Disfiguring lacerations<br>"Whiplash" severe complaints with anatomical or radiological evidence<br>**Chest**<br>Simple rib or sternal fractures<br>Major contusions of chest wall without hemothorax or pneumothorax or respiratory embarrassment<br>**Abdominal**<br>Major contusions of abdominal wall<br>**Extremities and/or Pelvic Girdle**<br>Compound fractures of digits<br>Undisplaced long bone or pelvic fractures<br>Major sprains of major joints | B |

| Severity Code | Severity Category/Injury Description | Police Code |
|---|---|---|
| 3 | **Severe (Not Life-Threatening)**<br>**General**<br>Extensive contusions; abrasions; large lacerations involving more that two extremities, or large avulsions (greater than 3" wide)<br>20-30% body surface 2° or 3° burns<br>**Head and Neck**<br>Cerebral injury with or without skull fracture, with unconsciousness more than 15 minutes; without severe neurological signs; brief; post-traumatic amnesia (less than 3 hours)<br>Displaced closed skull fractures without unconsciousness or other signs of intracranial injury<br>Loss of eye, or avulsion of optic nerve<br>Displaced facial bone fractures or those with antral or orbital involvement<br>Cervical spine fractures without cord damage<br>**Chest**<br>Multiple rib fractures without respiratory embarrassment<br>Hemothorax or pneumothorax<br>Rupture of diaphragm<br>Lung contusion<br>**Abdominal**<br>Contusion of abdominal organ<br>Extraperitoneal bladder rupture<br>Retroperitoneal hemorrhage<br>Avulsions of ureter<br>Laceration of urethra<br>Thoracic or lumbar spine fractures without neurological involvement<br>**Extremities and/or Pelvic Girdle**<br>Displaced simple long-bone fractures and/or multiple hand and foot fractures<br>Single open long-bone fractures<br>Pelvic fracture with displacement<br>Dislocation of major joints<br>Multiple amputation of digits<br>Lacerations of the major nerves or vessels of extremities | B |

| Severity Code | Severity Category/Injury Description | Police Code |
|---|---|---|
| 4 | **Severe (Life-Threatening, Survival Probable)**<br>**General**<br>Severe lacerations and/or avulsions with dangerous hemorrhage<br>30-50% surface 2° or 3° burns<br>**Head and Neck**<br>Cerebral injury with or without skull fracture, with unconsciousness of more than 15 minutes, with definite abnormal neurological signs; post-traumatic amnesia 3-12 hours<br>Compound skull fracture<br>**Chest**<br>Open chest wounds; flail chest; pneumomediastinum; myocardial contusion without circulatory embarrassment; pericardial injuries<br>**Abdominal**<br>Minor laceration of intra-abdominal contents (to include ruptured spleen, kidney, and injuries to tail of pancreas)<br>Intraperitoneal bladder rupture<br>Avulsions of the genitals<br>Thoracic and/or lumbar spine fractures with paraplegia<br>**Extremities**<br>Multiple closed long-bone fractures<br>Amputation of limbs | B |

| Severity Code | Severity Category/Injury Description | Police Code |
|---|---|---|
| 5 | Critical (Survival Uncertain)<br>General<br>Over 50% body surface 2° or 3° burns<br>Head and Neck<br>Cerebral injury with or without skull fracture with unconsciousness of more than 24 hours; post-traumatic amnesia more than 12 hours; intracranial hemorrhage; signs of increased pressure (decreasing state of consciousness, brady-cardia under 60, progressive rise in blood pressure or progressive pupil inequality)<br>Cervical spine injury with quadriplegia<br>Major airway obstruction<br>Chest<br>Chest injuries with major respiratory embarrassment (laceration of trachea, hemomediastinum, etc.)<br>Aortic laceration<br>Myocardial rupture or contusion with circulatory embarrassment<br>Abdominal<br>Rupture, avulsion or severe laceration of intra-abdominal vessels or organs, except kidney, spleen or ureter<br>Extremities<br>Multiple open limb fractures | A |
| 6 | Fatal (Within 24 Hours)<br>Fatal lesions of single region of body, plus injuries of other body regions of Severity Code 3 or less<br>Fatal from burns regardless of degree | K |
| 7 | Fatal (Within 24 Hours)<br>Fatal lesions of single region of body, plus injuries of other body regions of Severity Code 4 or 5 | K |
| 8 | Fatal<br>2 fatal lesions in 2 regions of body | K |
| 9 | Fatal<br>3 or more fatal injuries<br>Incineration by fire | K |
| 99 | Severity Unknown<br>Injured, but severity not known | |

| Severity Code | Severity Category/Injury Description | Police Code |
|---|---|---|
| 98 | Presence Unknown<br>Presence of injury not known | |

# APPENDIX B

# MACKINAC ISLAND INJURY SURVEY

## MACKINAC ISLAND INJURY SURVEY

Incident Date ______________________________

Incident Location ______________________________

(Be specific)

Incident Time __________AM __________PM
Circle one: AM: 6am-12 noon PM: 12 noon-8pm NOC: 8pm-6am

Incident Type (list all that apply): ______________________________

1. Bicycle/Bicycle 2. Bicycle/Horse 3. Bicycle/Pedestrian

4. Bicycle alone 5. Other: (describe)

Incident Severity: (1-5) ______________________________

| | | | |
|---|---|---|---|
| Victim able to continue on | | Yes | No |
| Victim taken to Island clinic | | Yes | No |
| Ambulance called | | Yes | No |
| Victim taken off island due to severity of injury | | Yes | No |
| Weather conditions | Rainy | Yes | No |
| | Snow | Yes | No |
| | No precip. | Yes | No |
| Fatality | | Yes | No |

Victim Name ______________________________

Victim Age __________years Gender M F

Did victim visit Health clinic within 24 hours following accident Yes No

Write a brief description of injuries

# APPENDIX C

# MODIFIED MACKINAC ISLAND INJURY SURVEY

## MODIFIED MACKINAC ISLAND INJURY SURVEY

Incident Date

Incident Location

Incident Time
Circle one: AM: 6am-12noon PM: 12noon-8pm NOC: 8pm-6am

Incident Type (list all that apply)
Bicycle/Bicycle_____
Bicycle/Horse_____
Bicycle/Pedestrian_____
Bicycle alone_____
Other (Describe)

Incident Severity
_____Critical (Survival uncertain or Fatal)
_____Severe (Incapacitating)
_____Non-Incapacitating
_____Minor
_____No Injury

Anatomical Location of Injury
Victim Age_____ Victim Gender_____

Did victim visit health clinic within 24 hours following accident
_____Yes _____No

Write a brief description of injuries

# APPENDIX D

# MODIFIED ABBREVIATED INJURY SCALE

# MODIFIED ABBREVIATED INJURY SCALE

Severity Code

Fatal - corresponds to #6 on AIS

Incapacitating - survival uncertain must be transported off island, corresponds to AIS 3,4, &5. Includes a wide range of injuries due to limited ability of island health clinic to treat critical or serious injury.

Non-incapacitating - corresponds to AIS 2.

Possible or Minor - corresponds to AIS 1.

No injuries - corresponds to Code 0 on AIS Scale.

# APPENDIX E

# AIS - 6 SEVERITY CODE

## AIS-6 SEVERITY CODE

1. Minor
2. Moderate
3. Serious
4. Severe
5. Critical
6. Maximum injury - virtually unsurvivable given our present medical capabilities, specific knowledge of the severity of injury must be available, not merely knowledge that death occurred.
7. Unknown

# APPENDIX F

## UCRHIS Approval

MICHIGAN STATE
UNIVERSITY

September 30, 1997

TO: Mary Hughes
B 311 D West Fee

RE: IRB#: 97-552
TITLE: INJURY PATTERNS IN ADULT AND PEDIATRIC BICYCLE RIDERS ON MACKINAC ISLAND
REVISION REQUESTED: N/A
CATEGORY: 1-E
APPROVAL DATE: 09/29/97

The University Committee on Research Involving Human Subjects'(UCRIHS) review of this project is complete. I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the UCRIHS approved this project and any revisions listed above.

**RENEWAL:** UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Investigators planning to continue a project beyond one year must use the green renewal form (enclosed with the original approval letter or when a project is renewed) to seek updated certification. There is a maximum of four such expedited renewals possible. Investigators wishing to continue a project beyond that time need to submit it again for complete review.

**REVISIONS:** UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB # and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.

**PROBLEMS/ CHANGES:** Should either of the following arise during the course of the work, investigators must notify UCRIHS promptly: (1) problems (unexpected side effects, complaints, etc.) involving human subjects or (2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of any future help, please do not hesitate to contact us at (517)355-2180 or FAX (517)432-1171.

Sincerely,

David E. Wright, Ph.D
UCRIHS Chair

DEW:bed

cc: Robert Prodinger
Elizabeth Klein
Mary Wilger

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