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Compulsory Bicycle Helmets: A Necessity Or a Superfluous Solution?

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COMPULSORY BICYCLE HELMETS:

A NECESSITY OR A SUPERFLUOUS SOLUTION?

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DEDICATION

I'd like to dedicate this manuscript to my father, Gerald Edwin Brown Jr., for providing me with the discipline and faith in myself to achieve all my dreams, and to my brother, Michael Scott Brown, for giving me the strength and the courage to overcome life's obstacles. This is for the both of you, whose presence in my life will never be forgotten, and whose perpetual love will live forever in my heart.

Time ... the healer of wounds ... the illuminator of insight

... the vesicle of all one's dreams.

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ABSTRACT

The incidence and economic impact of bicycle related injuries, especially among children less than 16 years of age, has led to an array of studies reporting statistics and strategies aimed at reducing the associated prevalence. Head injury, reportedly, is the leading cause of bicycle-related morbidity and mortality. Accordingly, advocation of compulsory bicycle helmets has become the focus of bicycle safety campaigns.

This manuscript examines the characteristics of bicycle-related accidents and campaigns including the nature of injuries sustained, program effectiveness, risk assessment, and societal impact, through the conductance of several meta-analyses. It discusses the potential consequences formidable methodological deficiencies may have on the disparate inferences possible, between a traditional comprehensive review of the literature, and a quantitative meta-analytic review of the literature. The impact of such deficiencies need to be considered by researchers, educators and policy makers, referencing this body of literature to make decisions that effect the general population of recreational cyclists in the United States. To date, this author is unaware of the existence of another manuscript utilizing the same statistical techniques in this area of research. Therefore, it is believed that the results of this study, provide unique and invaluable information to those seeking to draw inferences from the bicycle-related injury and safety prevention literature.

CHAPTER 1

INTRODUCTION

The bicycle serves many purposes. It provides an efficient means of transportation for some, a method of exercise for others, or simply a recreational apparatus used to fraternize with friends and family members. For generations, the latter purpose has generally been the primary intention of children, for whom the bicycle is often a prized possession. Recently however, a growing number of injury prevention researchers and various health care professionals have focused their attention on potential strategies to reduce the number of bicycle related accidents and subsequent injuries. The interest in the bicycle, and injuries associated with its use, stems from the growing popularity of the bicycle. Greensher (1988) reported that bicycle use surged ten-fold from 1950 to 1985, with a corresponding two-fold increase in bicycle related deaths (Greensher 1988). More specifically, Greensher (1988) noted that the proportion of children under the age of 15 years suffering bicycle related deaths rose approximately 7/15 from 1960 to 1985 (Greensher 1988). However, according to the U.S. Department of Transportation (1995) bicycle related road traffic fatalities has changed little since 1980, varying between 1.8 - 2.0% of all traffic accident fatalities, despite the many bicycle helmet campaigns and legislative measures promulgated over the last several years (U.S. Department of Transportation, 1980-1995 Reports).

The above statistics, together with sky-rocketing health care costs, have lead to a number of research studies, as well as educational, media and community campaigns, commentaries, and legislative measures targeting the safety of those riding bicycles. The efficacy of a bicycle helmet in the prevention of serious head injuries has become the focal issue of these strategies. Advocates of helmets are mainly health care providers who treat those injured in bicycle related accidents. They support their position with statistics that reveal the morbidity and mortality of those injured, the cost of the care for those injured, as well as providing similar data on comparisons between helmet and non-helmet wearers. Children under the age of 16 are the most targeted group, due to the propensity for bicycle-related injuries and deaths in this age group.

Bicycles can be inexpensive, found in many second-hand stores and garage sales, and passed down through children. This makes them attainable in lower income and poverty areas. However, the same may not be true for bicycle helmets. Reportedly, the cost of a bicycle helmet that meets minimum national standards for effective head protection varies between $25 and $89 (Fullerton and Becker 1991; Storo 1992). While this may be affordable by some, lower income and poverty laden families with several children, may not agree. Several safety programs have therefore included helmet subsidy coupons into their programs, in an attempt to entice leery potential buyers whose principle obstacle is cost. Ironically, the majority of these programs were, and continue to be, implemented in predominately white, middle and upper middle class communities, over-looking lower income and poverty stricken communities where injuries have been noted to be the highest, and where helmet subsidies are most needed (Pless 1995, Wise et al. 1985, Whitman et al. 1984).

The results of several studies abroad and in the United States have led to the passage of compulsory helmet wearing legislation in other countries, and in some areas of the United States. In July of 1990, Australia made it mandatory for all bicyclists to wear a helmet. New Zealand followed with a similar law in January, 1994. Two Provinces in Canada, Ontario and British Columbia, also passed mandatory helmet legislation. Ontario's law took effect on October 1, 1995, mandating all bicyclists under the age of 18 years to wear a bicycle helmet (Bicycle Helmet Safety Institute 1997). While British Columbia approved legislation requiring all cyclists to wear a bicycle helmet effective September, 1996 (Bicycle Helmet Safety Institute 1997). Two cities located in Canada's Quebec Province, Westmount and Cote Saint-Luc, passed similar bicycle helmet laws within their boundaries (Bicycle Helmet Safety Institute 1997). Cote Saint-Luc, reportedly, expanded their bicycle helmet law in October, 1997, to include bicyclists and skaters of all ages (Bicycle Helmet Safety Institute 1997).

Compulsory helmet legislation in the United States has been approved by various states and counties, cities, or localities within states. California was the first in the United States to impose any form of bicycle helmet legislation. Effective January 1, 1987, California mandated that all child passengers under the age of 5 years wear a helmet. Similar helmet laws were passed in New York (October 1, 1989), Massachusetts (December 1, 1990) and Pennsylvania (November 1, 1991). Each of these states subsequently revised their legislations. On January, 1, 1994, both California and

Massachusetts revised their original bicycle helmet legislation. California expanded its initial mandate to encompass all bicyclists under the age of 18 years, while Massachusetts' legislation was broadened to require all children under the age of 13 years to wear a bicycle helmet. A New York modification ensued on June 1, 1994, requiring all bicyclists under the age of 14 years to don a helmet. Similar to the above three states, Pennsylvania likewise amended its legislation on March 31, 1995 to include all children under the age of 12 years.

Six states, Georgia (July 1, 1993), Oregon (October 1, 1993), Alabama (September 19, 1995), Maryland (October 1, 1995), Delaware (April 1, 1996), and Florida (January 1, 1997) all enacted legislation mandating bicycle helmet use for children under the age of 16 years (World Health Organization Helmet Initiative Home Page 1996, Bicycle Helmet Safety Institute 1997, Resnick et al. 1995, and Storo 1992). Both Connecticut (October 1, 1993) and Tennessee (January 1, 1994) passed laws requiring all children under the age of 12 years to wear a bicycle helmet (World Health Organization Helmet Initiative Internet Home Page 1996, Bicycle Helmet Safety Institute 1996). Connecticut subsequently amended its mandate to include all cyclists under the age of 15 years in October, 1997, the same age requirement adopted in West Virginia on June 7, 1996 (Bicycle Helmet Safety Institute 1997). The first state to impose legislation requiring all children under 14 years to wear a bicycle helmet was New Jersey on July 1, 1992. Rhode Island adopted the least inclusive helmet laws on July 1, 1996, requiring helmet use for all those under the age of 9 years (World Health Organization Helmet Initiative Internet Home Page 1996, Bicycle Helmet Safety Institute 1997).

The passage of legislation by local jurisdictions preceded the majority of state-wide mandates. Howard County, Maryland, was the first region in the United States to implemented mandatory helmet use for all children under the age of 17 years in 1990 (Cote et al. 1992, Dannenberg et al. 1993, Bicycle Helmet Safety Institute 1997). Other local precincts enacted bicycle helmets laws for children under the age of 18 years, Montgomery County, Maryland (9/91), Tucson, Arizona (12/93), Clarksburg, West Virginia (1993), South Charleston, West Virginia (1994), Houston, Texas (7/95), St. Albans, West Virginia (1995), East Grand Rapids, Michigan (1995), Poulsbo, Washington (1995), Bedford, Texas (2/96), Fort Worth, Texas (9/96), Austin, Texas (1996), Arlington, Texas (1997), and Yuma, Arizona (1997) (World Health Organization Helmet Initiative Internet Home Page, 1996; Bicycle Helmet Safety Institute, 1997). Both Benbrook, Texas (1996) and Port Washington, Wisconsin (3/27/97) passed legislation requiring all cyclists under the age of 17 years to wear a bicycle helmet. Several communities have enacted legislation mandating that all cyclists under the age of 16 years don a bicycle helmet. These communities include Beachwood, Ohio (12/90), Chapel Hill, North Carolina (4/92), Allegheny County, Maryland (5/92), Carolina Beach, NC (1994), Eatonville, Washington (1996), and Carrboro, North Carolina (09/16/97). Even more areas passed mandates requiring children under the age of 15 years to wear a bicycle helmet while riding, including various jurisdictions in the state of Virginia -- Arlington County, Virginia (7/93) and Fairfax County, Virginia (7/94), Alexandria, Virginia (6/94), Blacksburg, Virginia (7/94), and Virginia Beach, Virginia (7/95), Prince William County, Virginia (1995), Manassas, Virginia (1995), Front Royal, Virginia (1996), Newport News, Virginia (1997), and Manassas Park, Virginia (1997), and Chemung County, New York (1995) (World Health Organization Helmet Initiative Home Page, 1996; Bicycle Helmet Safety Institute, 1997). Unlike the above regions, the town of Guilderland, New York (12/92) established legislation mandating all children under the age of 14 years wear a bicycle helmet when riding their bicycles on public roads, while Orange Village, Ohio (11/92) issued a city-wide law specifying that children cyclists aged 6 to 15 years were required to wear a bicycle helmet (World Health Organization Helmet Initiative Home Page 1996, Bicycle Helmet Safety Institute 1997). The least age restrictive community bicycle helmet requirement was adopted by Strongsville, Ohio, which mandated that all cyclists under the age of 12 years wear a bicycle helmet while riding (Bicycle Helmet Safety Institute 1997)

Distinct from the above areas, the following local jurisdictions mandated that all bicyclists, regardless of age, wear a bicycle helmet: Chico (Bidwell Park), California (7/91), Rockland County, New York (10/92), Clarkesville, Tennessee (4/93), Erie County (Parks), New York (6/93), King County (excluding Seattle), Washington (3/93), Montevallo, Alabama (9/93), Morgantown, West Virginia (1993), Port Angeles, Washington (1993), Homewood, Alabama (1/94), Greenburgh, New York (6/94), Pierce County, Washington (9/94), Tacoma, Washington (1994), Puyallup, Washington (1994), Sykesville, Maryland (7/95), Steilacoom, Washington (1995), Boone County, North Carolina (1995), Fircrest, Washington (1995), Austin, Texas (5/96) and Dallas, Texas (9/96), Black Mountain, North Carolina (1996), University Place, Washington (1996), Gig Harbor, Washington (1996), Coppell, Texas (1/1/97), and Barrington, Illinois (3/6/97) (Bicycle Helmet Safety Institute 1997).

Despite the legislation and the medical evidence demonstrating the importance of helmets in the prevention of serious head injuries, some cyclists of all ages, are not willing to wear one. An array of reasons including peer pressure, an unappealing nature, uncomfortable or distractful feeling, cost, parental views that their child would not wear one, and loss of independence have all been cited (Ashbaugh , Macknin & Medendorp 1995; Coppens and McCabe 1995, Rodgers 1995, Cushman 1994, Runyan, Earp, & Reese 1991; DiGuiseppi, Rivara, & Koepsell 1990). In addition, greater restrictions on current legislation, or initial helmet laws, are being challenged or deferred in many states including Arizona, Colorado, Connecticut, the District of Columbia, Hawaii, Illinois, Iowa, Kansas, Maine, Missouri, Mississippi, Montana, Nevada, New Jersey, New Mexico, North Carolina, Ohio, Texas, Vermont, Washington, and Wisconsin (World Health Organization Helmet Initiative Home Page 1996, Bicycle Helmet Safety Institute 1997).

Thus, it is apparent that various legislators at both the local and state level, have acted upon the recommendations from bicycle helmet coalitions, medical professionals, and injury prevention researchers. A primary aim of this manuscript, however, is to determine if this suggestion is justifiable, or if it is a superfluous solution to pacify vociferous members of our society. This manuscript will attempt to determine whether a quantitative synthesis using meta-analytic procedures with the research associated with bicycle-related injuries and preventative measures, has significantly and consistently shown that commonly proposed bicycle safety measures reduce the risk and incidence of bicycle-related injuries and fatalities. This study will examine all injuries, as well as focus on bicycle-related head injuries, orthopedic injuries, and "other" (all other injuries), to determine if a reduction in one type of injury, may produce a concomitant rise in the reported incidence of another type of injury. Furthermore, the prevalence of helmet use pre and post various interventions, recorded in accident and injury documents, and by study characteristics will also be examined.

While the above issues will form the primary hypotheses, and pattern the tests of significance of the associated effect sizes of this study, various sub-hypotheses are also of interest. Methodological issues related to sample selection lead to the exploration of the following secondary issues: 1.) Has research demonstrated a significant benefit from bicycle helmet legislation, for all children, regardless of their families' socioeconomic level or race? and 2.) Have proponents of helmet use made a concerted effort to reach out to lower income and minority families? These matters are important considering that the mandate of bicycle helmets by all individuals, effects all individuals, and not just a selected sample of those included in research studies. Moreover, in light of the fact that families residing in lower income communities generally have more pressing issues such as gang violence, drug abuse and dealers, drive-by shootings, lack of health insurance, and high unemployment rates, is it equitable to require parents to purchase bicycle helmets for their children or risk fines levied upon them? Imposing mandatory helmet use on these communities, which are often confounded by a racial factor, has the potential to take away a simple pleasure from these children, who are already forced to forego much of their youth.

Lastly, variables perceived to be associated with the type and severity of injury, and thereby indirectly with helmet usage will also be collected, and statistical analyses run to identify what contribution, if any, they have in the incidence, type, and severity of bicycle-related injuries. These factors include age, gender, race, and the type, cause, location, season, and time of day of reported bicycle accidents.

The Problem

Statement of the Problem

Bicycle related injuries account for a large percentage of serious injuries and fatalities in children. The National Electronic Injury Surveillance System (NEISS), a data collection system used to gather product-related injuries treated in emergency rooms, estimated over 500,000 individuals received emergency care for bicycle-related injuries in 1985 (Center for Disease Control 1987). Head injuries reportedly accounted for the largest percentage of morbidity and mortality associated with bicycle related accidents (Thomas et al. 1994, Li et al. 1995). As such, researchers have been implementing various strategies in an attempt to reduce these staggering numbers.

Bicycle safety and bicycle helmet usage programs have been shown to be effective in reducing these statistics. However, methodological limitations related to the design and subject selection of published research have prohibited the acquisition of incontrovertible evidence favoring the mandate of bicycle helmet legislation. Advocates of helmet regulation for bicycle riders purport that it is different from the controversial motorcycle helmet legislation because we are dealing with the youth of our society. However, just as adults are capable of protesting against measures they feel are unconstitutional, so to are adolescents and teenagers who are notorious for rebellious behavior as they explore various sociocultural aspects on their path to adulthood. It is those youth who experiment with socially deviant identities who are most likely to engage in high-risk behavior that results in serious injury, not those who are most likely to conform to parental and authoritative rules (Pless et al. 1995). Therefore, while mandating bicycle helmet legislation may be effective for those willing to comply after receiving some type of educational prevention in-service, will it be effective for those at greatest risk?

In addition to risk-takers, members of lower income and poverty stricken communities also warrant consideration. These individuals have largely been over-looked in the majority of studies that focus on the efficacy and feasibility of bicycle helmets. Lack of educational programs and finances are generally at the core of their participatory exclusion. However, socioeconomic disparities, which often coincide with racial disparities, have been noted to be negatively associated with injury and mortality data (Pless et al. 1995, Wise et al. 1985, Whitman et al. 1984). In consideration of these issues, speculation as to whether those individuals at highest risk of experiencing serious bicycle-related head injuries, are identical to those individuals who currently are the focus of many preventative strategies may require serious attention.

Bicycle safety campaigns, whether community, educational, legislative, or some combination of these, generally rely on behavioral modification to produce their desired effect, in this case, to increase helmet usage among all cyclists. As such, these measures all incorporate application of behavioral analysis to some extent. The use of legislation for this purpose, recollected a quote by B.F. Skinner, the founder of behavioral analysis, who, in reference to political control wrote (1983, p . 421):

> "Very often one who tries to analyze political control is challenged . . . and it is implied that success or failure in following one's recommendation would be a test of the underlying principles. But any one case is a unique assemblage of conditions, not all of which are known or within reach. However, if we accept, not on faith but on the evidence of controlled experiments, the validity of certain behavioral processes, we may make a sustained application not easily deflected by occasional failure. Possibly we could write a guide, . . . , which would indicate the better of two courses, other things being equal. Only in the long run would this be supported by significant improvement; in the short run support would have to come from the scientific analysis."

This study aims to use meta-analytic techniques to quantitatively synthesize published findings on the efficaciousness of bicycle helmets in the United States. Because the various interventions used by researchers and injury prevention centers to encourage bicyclists to use helmets all involve applications of behavioral analysis, it seems appropriate to heed the advice of its founder. Moreover, we cannot ignore that bicycle safety programs and interventions often rely on "positive reinforcement," "negative reinforcement," or both, in their approaches to increasing helmet usage. For example, bicycle rodeos, fast food discount coupons, and similar enticements have been rewards for children who elected to don bicycle helmets. Conversely, mandatory legislation and parental pressure, may be viewed as forms of "negative reinforcement." However, Nye (1992) reminds us that Skinner believed that, "A sign of an inefficient and poorly planned society is a heavy reliance on negative reinforcers to control behavior " (p. 20). Furthermore, Nye submits that positive reinforcement is preferred to negative reinforcement because, ". . . outcomes of positive reinforcement are more predictable than those of negative reinforcement. Undesirable behavior often gets strengthened by negative reinforcement" (p. 20). Thus, it will be interesting to see whether mandated helmet usage, a form of negative reinforcement, proves to have a long-term beneficial role in the use of bicycle helmets, and the reduction of bicycle related injuries, specifically bicycle related head injuries. Should this be true, it would be expected that the associated effect size estimates would increase (helmet use) or decrease (injury rates) as study publication dates become more recent.

The Purpose of the Study

This manuscript will present a comprehensive review of the literature related to the incidence and epidemiology of bicycle related injuries, with an emphasis on head injuries. The programs and strategies to promote helmet use, effectiveness of helmets, assessment of potential risk reduction, and the role of socioeconomic status and race will be addressed. An evaluation of the length of hospitalizations and associated costs of bicycle-related accidents, will also be examined, but no analyses will be conducted on these variables. The review of this information is to provide the reader with insight into the economic impact bicycle-related injuries and rehabilitation can have on society.

Variations of meta-analytic techniques will be used to analyze the data. Accordingly, integration of the findings from numerous studies with a similar primary or secondary focus will be performed. Although the primary sample population of this manuscript is the recreational cyclist, information has been gathered on avid cyclists as well (i.e., members of cycling organizations and professional cyclists). While no analytical comparisons will be made between these two populations of cyclists, an attempt will be made to identify any significant difference in helmet use, and type and severity of injury, between these two cycling populations. The aim of this inquiry is to amalgamate the various strategies and resultant data currently used in the efficacy assessment of bicycle helmet use, and determine whether legislation mandating helmet use is both essential and equitable, to all members of our society.

Significance of the study

Conductance of this research is intended to provide medical professionals, educators, and injury researchers with knowledge of the most beneficial methods in the promotion of bicycle safety and the prevention of bicycle related injuries. Special attention will be given to head injuries, which are the leading cause of morbidity and mortality from bicycle related accidents. Acquisition of this information will permit the identification of those strategies that demonstrate a significant influence in the prevention of bicycle related injuries. In addition, awareness of the measures found to be most successful, together with those that need to be addressed or modified, may help all professionals involved in this area of injury prevention, to structure a formidable attack against this mechanism of injury. Ultimately, a comprehensive understanding of the relevant factors related to bicycling injuries will allow precious resources to be expended with greater assurance of their usefulness.

General Hypotheses

It is hypothesized that evidence will be found to confirm the effectiveness of bicycle helmets in the prevention of serious head injuries. Bicycle safety programs with a multi-faceted design combining educational, community, and media measures are anticipated to be the most successful. However, it is also postulated that the vast number of aggressive preventative strategies currently in place, exclude some of the individuals at highest risk -- impoverished individuals and minorities. Ideal programs that target the issues central to all members of the high risk population: children, risk-takers, minorities, and impoverished individuals are not foreseen to be the norm.

The pattern of injuries sustained by bicyclists will be examined for all cyclists, followed by separate assessments for helmeted and non-helmeted cyclists. Abrasions contusions, and lacerations are expected to be the most prevalent injuries sustained by cyclists of all ages. Orthopedic injuries are postulated to be the primary injury sustained by all cyclists seeking medical treatment. In contrast, neurologic injuries, specifically head injuries, are anticipated to be the major cause of mortality resulting from bicycle-associated accidents. The pattern of injuries sustained by helmeted and non-helmeted cyclists is hypothesized to differ. While orthopedic injuries are expected to predominate for both helmeted and non-helmeted cyclists, a greater number of orthopedic injuries, namely spinal cord and extremity injuries, are suspected to be incurred by helmeted cyclists.

Accident characteristics are expected to distinguish bicycle-motor vehicle collisions of adults and children. Cyclist error, including risk taking behaviors such as speeding and stunts, and failure to follow traffic rules are predicted to predominate among children. Conversely, motorist error and road conditions are anticipated to prevail among adults.

Assumptions and Limitations

1. Only published articles were included in the analyses. Unpublished works were not ascertained because of time constraints. Therefore, the presence of publication bias cannot be excluded, and its potential to favor the political and medical idealogies of the time must be considered.
2. The intent of this author was to perform a comprehensive review of the published literature. No study providing sufficient information for use in this meta-analysis was deliberately excluded from any analyses. Any study that may have been excluded was done so inadvertently.
3. Some studies obtained data for all pedalcyclists (bicycles, tricycles & other pedal powered vehicles) while others included bicycles only. Due to the small percentage of tricycles and other pedal powered vehicles, this manuscript refers to them all as bicycles.
4. It is assumed that the studies chosen for integrative analysis all resulted from quality individual research studies.
5. Established techniques will be used to reconstruct the data when statistics necessary to calculate effect sizes are not directly provided.

6. For purposes of analysis, the term head injury will refer specifically to brain or skull injuries. This means that facial injury, ear injury, eye injury, and neck injury will not be included in the determination of the number of head injuries, when detailed data allows for the separation of injuries according to this criteria. Studies that do not distinguish between these types of injuries will be identified, and, if possible, an attempt will be made to determine whether this type of reporting effects the results of the effected meta-analyses. This decision was made because a bicycle helmet does not protect the aforementioned areas, and therefore inclusion of such injuries with head injuries, has the potential to provide misleading information. Moreover, an overestimate of the number of head injuries is likely, as some researchers identified injuries solely as head and neck, or mentioned that ear injuries were included in the report of head injuries, without indicating the exact number of all such cases.

CHAPTER 2

REVIEW OF LITERATURE

Bicycle riding has increased markedly over the last 2 decades. The U.S. Consumer Product Safety Commission provides convincing evidence of its astounding growth by noting that it was the 3rd most popular U.S. recreational activity in 1991, averaging over 11 million shipments to U.S. retailers since 1987 (Rodgers 1994). In New York State alone, more than 750,000 bicycles were sold during 1989 (Division of Epidemiology 1990). In addition, the introduction of the all terrain bicycle or mountain bicycle in the western United States in the late 1970's, has reportedly enhanced the popularity of cycling even further over the last 10 years (Pfeiffer & Kronisch 1995; Chow, Bracker & Patrick 1993). Bicycles are not exclusively used for recreational or exercise purposes, rather they are also used as a cost-efficient, and fuel-conserving means of transportation to and from work. Accordingly, this outburst of interest in cycling has contributed to more cyclists on the road, and thus more cycling accidents.

National Incidence of Bicycle-Related Injuries

Statistics and Trends

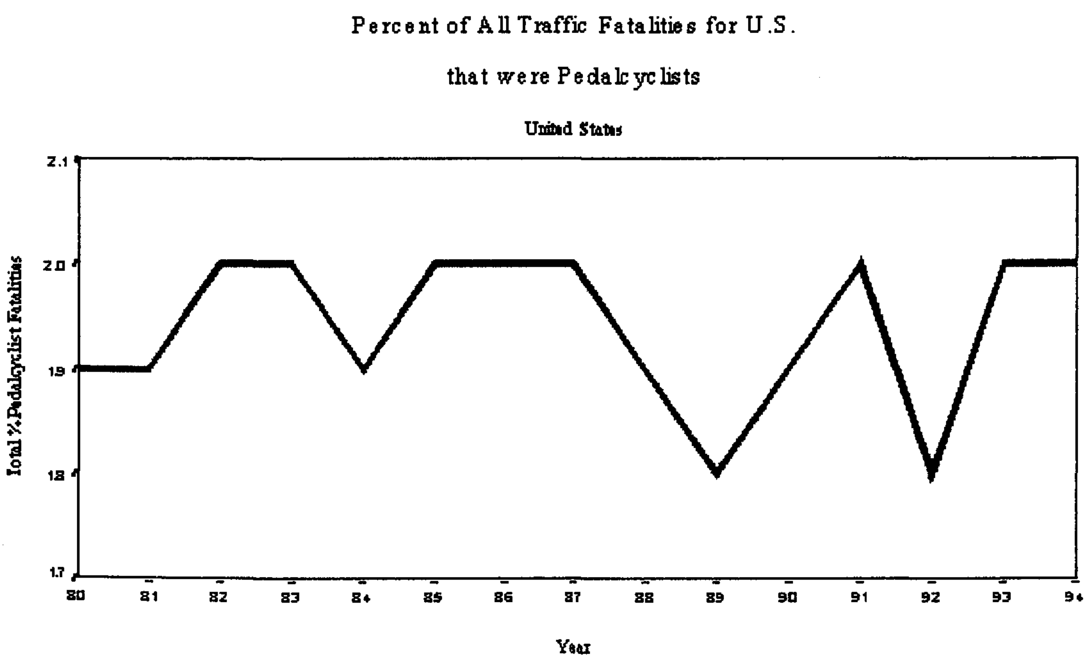
One of the earliest examinations of bicycle associated accidents, nationally, was conducted by Flora & Abbott (1979). Flora and Abbott (1979) reviewed the data collected by the U.S. Consumer Product Safety Commission's (CPSC) National Electronic Injury

Surveillance System (NEISS) for the period 1973-1976 (Flora & Abbott 1979). This data is based on the information acquired from various contributing hospitals' emergency department admissions. At first glance of the data, Flora & Abbott (1979) noted a gradual increase in the estimated number of cycling related injuries. However, application of statistical projection analyses to the estimated monthly bicycle associated accidents, adjusting for season, produced a nonsignificant finding. This means that the increasing trend may have occurred by chance, and thus was not significant over the period analyzed.

More detailed review of the data collected by NEISS revealed a predominance of bicycling accidents among males, cyclists less than 15 years of age, and accidents resulting from bicyclist error (Flora & Abbott 1979). Furthermore, Flora & Abbott's examination of bicycle-related injuries, revealed that only 8% of all bicycle-related injuries were serious injuries. Thus, they concluded, "that the number of bicycle accidents appeared to be a stable phenomenon, and that the total number of bicycle accidents did not increase significantly over a 4-year period" (p.6). The discrepancy noted in the interpretation of bicycle-related injuries at first glance, and later over time (i.e., an increasing trend, later contradicted by the nonsignificant finding upon more critical review of the data) was postulated by Flora & Abbott (1979) to potentially be attributed to a reduction in the rate of bicycle-related accidents per cyclist.

Data from NEISS was reviewed a decade a later by the Centers for Disease Control (1987), for a two week period in 1986. Similarly, gradual increase in the estimated number of cycling related injuries was reported (Centers for Disease Control 1987). According to the 1987 publication in JAMA, NEISS registered 3298 injuries in its database for the period September 15-28, 1986. Of these 101 (3.1%) were bicycle-related injuries. Extremity injuries comprised 37% of all bicycle injuries, followed by injuries to the face and neck (19/101, 18.8%), trunk (8/101, 7.8%) and lastly head (5/101, 5%). Multiple injuries were reportedly experienced by 11.9% (12/101), with injuries classified as "other" accounting for 19.8% (20/101) of all injuries. Only 5 of the 101 (5%) injured cyclists were hospitalized, and there were no deaths. Reportedly, 98% (99/101) of all accidents occurred on non-public roadways, and more than 50% of all bicycle accidents were sustained by those aged 5-14 years. Comparable statistical analyses applied to the estimated monthly bicycle associated accidents, adjusting for season, were not conducted in this later publication, thereby prohibiting comparison with the results reported by Flora & Abbott (1979).

Figure 1:



According to the U.S. Department of Transportation (1995) bicycle related accidents accounted for 2% of all road traffic fatalities in 1994. This statistic has changed little since 1980, varying between 1.8 - 2.0% of all traffic accident fatalities, despite the many bicycle helmet campaigns and legislative measures promulgated over the last several years (U.S. Department of Transportation, 1980-1995 Reports) (See Figure 1). Moreover, Arizona, Florida, and Hawaii most frequently documented pedalcyclist fatality percentages above the national average (2%) for all traffic crash fatalities. However, the District of Columbia (6.0%), Delaware (5.2%), and Arkansas (5.1%) reported the highest statewide pedalcyclist traffic accident fatalities during 1992, 1980 and 1993, respectively (U.S. Department of Transportation, 1980-1995 Reports) (See Figures 2-6). Overall, pedalcyclist collisions with motor vehicles appear to have declined since 1980; accounting for 965 traffic fatalities in 1980 and 802 in 1994. However, like the national percentage for all road traffic fatalities reported above, these numbers have also fluctuated over the years; increasing in late 1980's, but having the lowest incidence in 1992 (723 pedalcyclist traffic related fatalities) (U.S. Department of Transportation, 1980-1995 Reports). More detailed examination of these statistics reveal that children aged 10-15 years appear to show the greatest reduction in traffic related fatalities, as evident by the gradual decline from 314 in 1980, to 175 in 1994.

Figure 2:

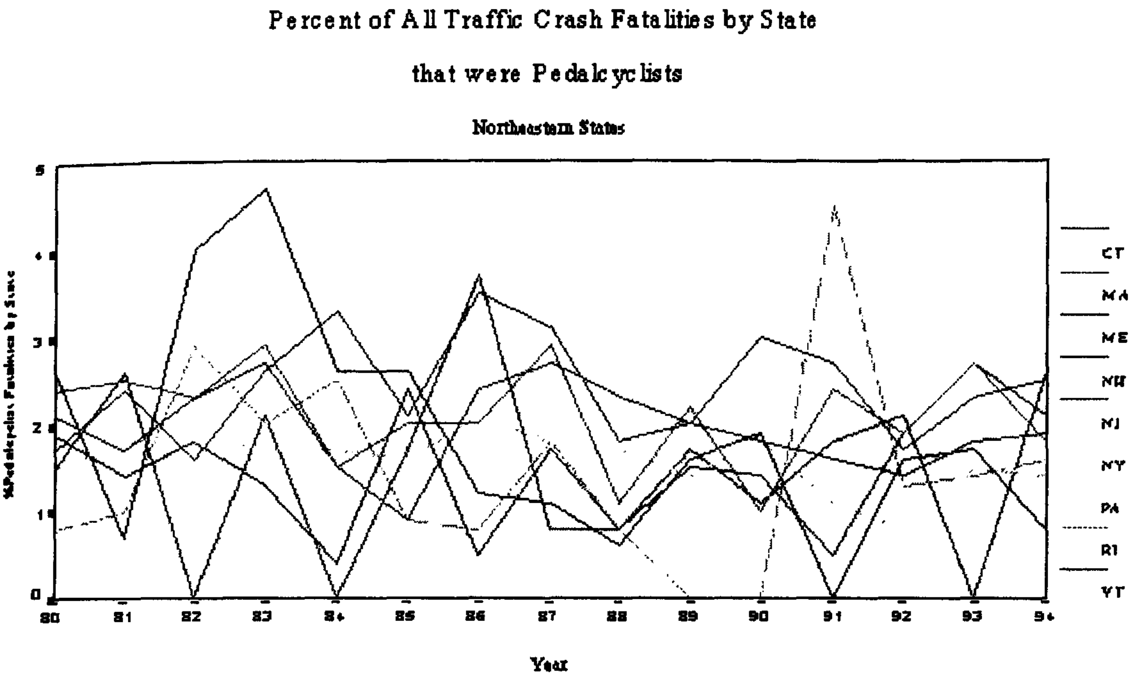


Figure 3:

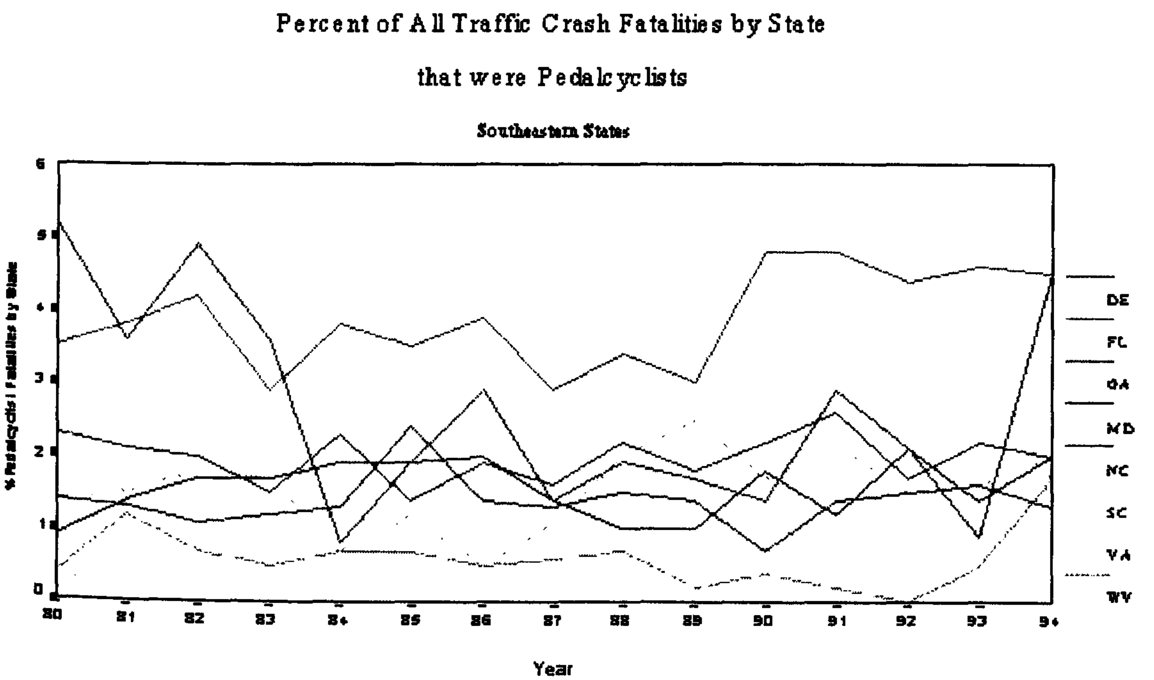


Figure 4:

Percent of All Traffic Crash Fatalities by State

that were Pedalcyclists

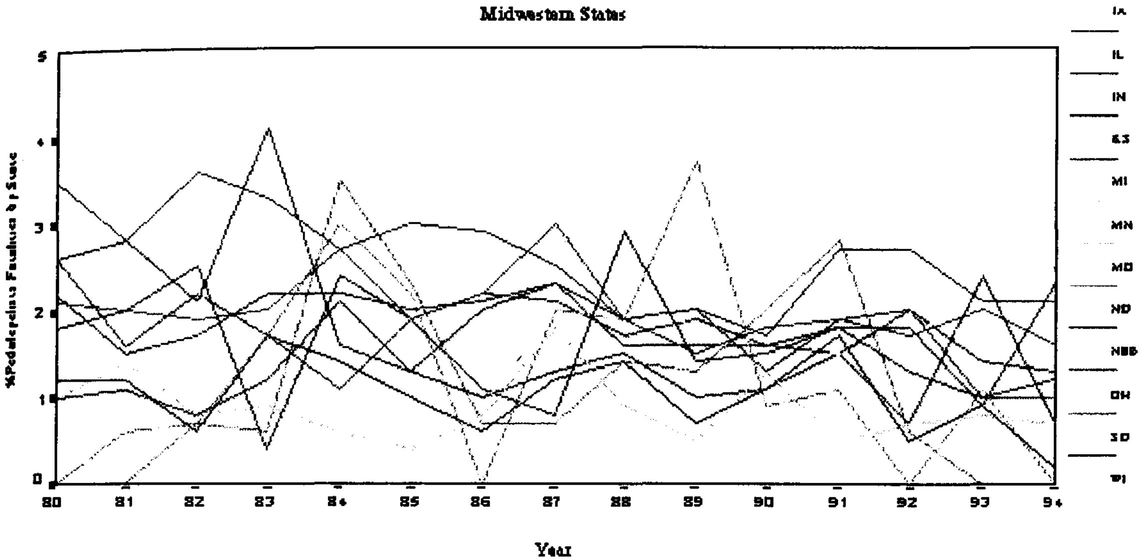


Figure 5:

Percent of All Traffic Crash Fatalities by State

that were Pedalcyclists

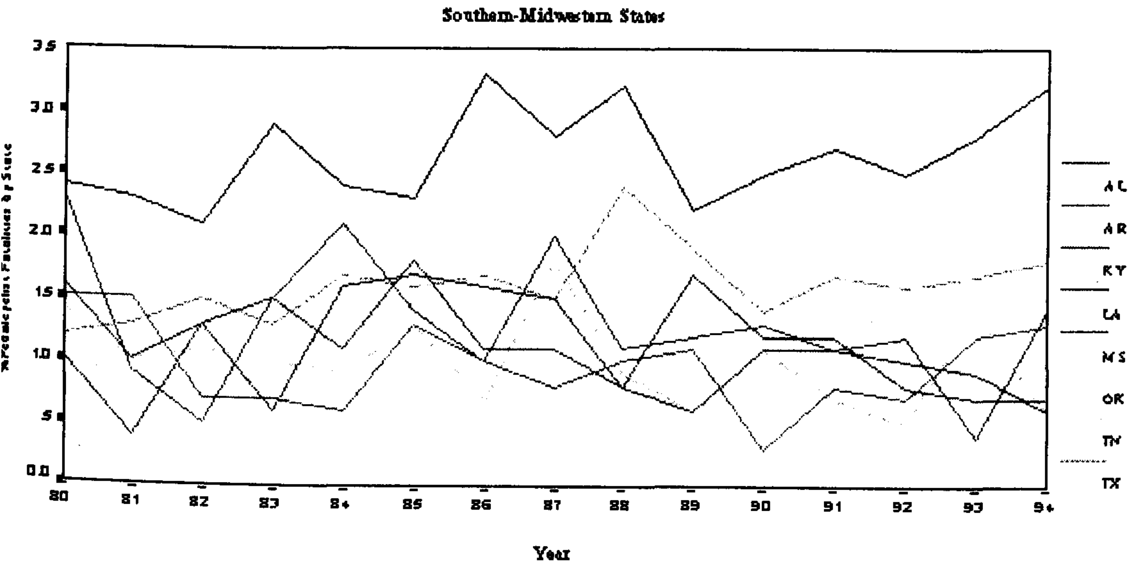
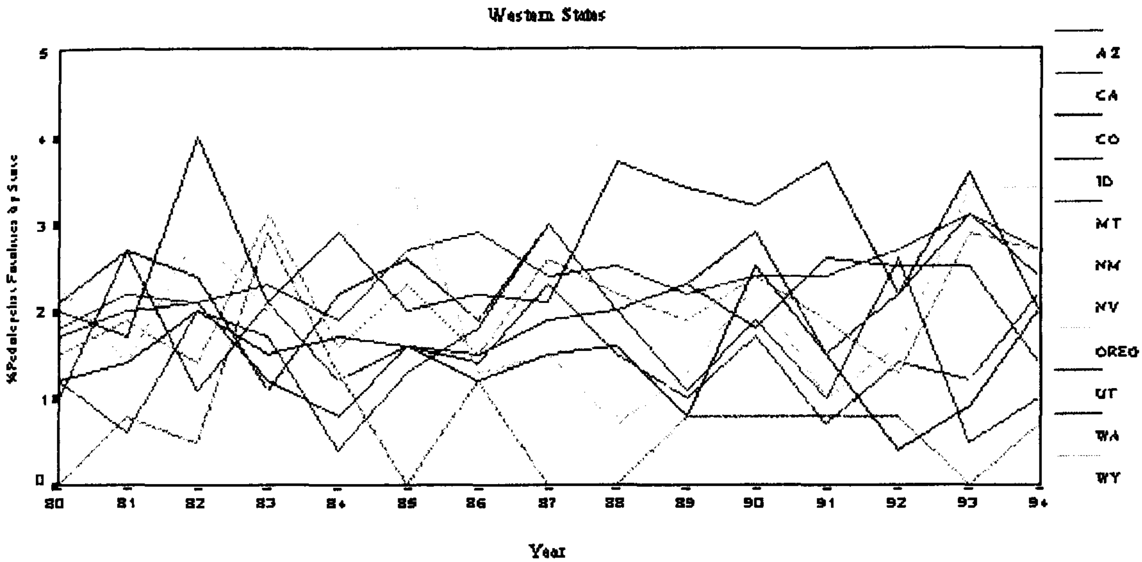


Figure 6:

Percent of All Traffic Crash Fatalities by State

that were Pedalcyclists



According to the U. S. Department of Transportation (1980-1995 Reports) three primary factors associated with pedalcyclist fatalities have remained unchanged since 1980. These include: 1.) a preponderance of male pedalcyclist fatalities, 2.)cyclists error when fault is determined in bicycle-motor vehicle collisions, and 3.) the time of day and day of week when most traffic related pedacyclist deaths occur. Factors pertaining to errors in cyclist behavior are continually reported as responsible for more than 50% of all fatalities when pedalcyclist-motor vehicle crashes are analyzed (56% in 1993 and 60% in 1994). Cyclist fatalities among males are not only prevalent, but have shown an increasing trend over the years; 81% in 1980, 84% in 1985, 85% in 1989, 87% in 1993, and 86% reported in 1994. Furthermore, although statistics published by the U.S. Transportation Department have revealed a decline in the number of bicycle-related traffic fatalities among children aged 10-15 years, this age group continues to sustain the greatest percentage of such deaths (32% in 1980, 31% in 1985, 27% in 1989, 23% in 1993, and 22% in 1994) (US Dept. of Transportation, 1980-1995). Lastly, pedalcyclist-motor vehicle collisions have consistently occurred most frequently between the hours of 3-6 PM, both during the week and on the weekend; a pattern prevalent since 1980 (U.S. Department of Transportation, 1980-1995 Reports).

Examination of the data provided by the U.S. Department of Transportation for pedalcyclists injured in traffic related accidents revealed that the number of incapacitating pedalcyclists injuries rose slightly from 14% in 1993 to 17% in 1994, while the number of non-incapacitating injuries declined from 54% in 1993 to 47% in 1994. Thirty-two percent of those injured in 1993 and 35% of those injured in 1994 were classified as "Other" indicating that injury severity was unknown (US Dept. of Transportation, 1995). Comparable data from earlier years was not provided by the U.S. Department of Transportation.

Inspection of the pedalcycle injury data weighted by age and sex and reported by the U.S. Department of Transportation from 1988-1994, shows that the injury data for females aged 5-44 years has fluctuated little since 1990. Conversely, a gradual decline can been seen in males comprising the same age categories, since 1990.

Li and Baker (1995) accessed the Fatal Accident Reporting System (FARS) of the

National Highway Traffic Safety Administration to evaluate the extent of alcohol involvement in fatally injured bicyclists from 1987 through 1991. This is the same database which monitors the traffic related pedalcyclist fatalities noted above. Li and Baker (1995) evaluated the role of alcohol in the accidents of these cyclists, aged 15 years and older. They revealed that 2694 bicyclists were fatally injured during this time period, but only 1711 were tested for alcohol. Of those tested, 1520 (89%) were male, and 191 (11%) were female. The largest percentage of cyclists, for both males (1005/1520, 66.1%) and females (164/191, 85.9%) had a blood alcohol level (BAC) of zero. Among those who tested positive for alcohol, prevailing accident characteristics included, bicyclists who were aged 25-34 years, cycling at night (7:00 p.m. to 6:59 a.m.), on a "normal" (non-inclimate weather) day, during the week, and on roadways with posted speed limits of 35 mph or above (Li and Baker 1995). Reportedly, no difference was noted in those who tested positive versus negative for blood alcohol, for the following factors: 1.) location - urban versus rural, 2.) scene of accident - highways versus local routes, 3.) type of road - junction versus nonjunction, and straight versus curved roads, and 4.) weather conditions at the time of the accident - "normal" weather versus inclimate weather (rain/snow/fog) (Li and Baker 1995).

Because information on substance abuse, namely alcohol level, is rarely reported in the bicycle injury literature, meta-analysis on this information will most likely not be feasible. However, in lieu of the many efforts to reduce the number of intoxicated automobile and motorcycle drivers, it may be interesting to examine whether there is a shift from intoxicated automobile and motorcycle drivers, to bicycle riders. Certainly, the intoxicated bicyclist riding on a public roadway would appear to be more vulnerable to sustaining more severe injuries than the motorist, if involved in a collision with a motor-vehicle. Thus, monitoring the role of alcohol in bicycle-related accidents, especially those involving motor vehicles, may be worthy of consideration.

Because not all bicycle-related traffic accidents may be included in the U.S. Department of Transportation Summary Reports, simultaneous review of bicycle-related injuries collected for NEISS may provide a more accurate reflection of national incidence rates. However, whether or not a national trend representing a significant increase in cycling related injuries is acknowledged, consideration ought to be given to the growth in bicycle sales and to the enhancement of monitoring techniques employed over the years which allow for better identification of cycling injuries.

Estimates from Defined Populations

In an attempt to formulate an estimate of the incidence and associated epidemiologic data of bicycle-related injuries and fatalities, numerous studies have been conducted. Methodological variations include both retrospective and prospective analysis of hospital data, medical examiners' records, registry data, observational studies, administration of questionnaires and surveys, or some combination of the above. Of these studies, those whose primary focus was on the bicyclist, took place in limited geographical regions or with select subject populations (Kronish, Chow, Simon, & Wong 1996; Ashbaugh, Macknin, & Medendorp 1995; Frank, Frankel, Mullins & Taylor 1995; Hawley, Clark, & Pless 1995; Spaite, Criss, Weist, Valenzuela, Judkins and Meislin 1995; Yelon, Harrigan & Evans 1995; Zavoski, Lapidus, Lerer, & Banco 1995; Largo & Thacher-Renshaw 1993; McKenna, Welsh, & Martin 1991; Nakayama, Gardner, & Rogers 1990; Thompson, Thompson, & Rivara 1990; Rivara et al. 1989; McLennan, McLennan & Ungersma 1988; Tucci & Barone 1988; Selbst, Alexander & Ruddy 1987; Kiburz, Jacobs, Reckling, & Mason 1986; Watts et al. 1986; Friede, Azzara, Gallagher, & Guyer 1985; Fife et al. 1983; Ernster & Gross 1982; Halek, Webster, & Hughes 1980; Waller 1971). An additional number of bicycle-related studies have focused principally on the incidence and severity of bicycle-related head injuries (Li et al. 1995; Thomas et al. 1994; Sacks, Holmgreen, Smith, & Sosin 1991; Belongia, Weiss, Bowman, & Rattanassiri 1988; Wasserman, Waller, Monty, Emery, & Robinson 1988; Kraus, Fife, & Conroy 1987). Other studies aimed to examine all injuries or mortalities, or those resulting solely from head injuries in some defined population or community. The latter of these studies chose to distinguish injuries or mortalities attributable to bicycle accidents, as a separate mechanism (Boswell, Boyd, Schaffner, Williams, & Frantz 1996; Scheidt et al. 1995; Schiller, Knox, & Chleborad 1995; Warren, Moore, & Johnson 1995; Vane et al. 1993; Cowan, Cannon, Hathcock, & Konigsberg 1993; Jaffe et al. 1993; King 1991; Hopkins, Writer, Mortensen, & Indian 1990; Kraus, Rock, & Hemyari 1990; Runyan, Kotch, Margolis, & Buescher 1985; Rivara 1985; Gallagher, Finison, Guyer, & Goodenough 1984; Whitman et al. 1984; Walker & Raines 1982; Rivara, Bergman, LoGerfo, & Weiss 1982; Klauber, Barrett-Connor, Marshall & Bowers 1981; Kraus et al. 1984; Annegers, Grabow, Kurland, & Laws 1980). Similar to head injury researchers, three groups of researchers sought to evaluate skeletal or spinal cord injuries by etiology for a defined region (Mackersie, Shackford, Garfin, & Hoyt 1988; Gerhart 1991; Rosenberg, Gerhart, & Whiteneck 1993).

In order to examine the characteristic patterns and predisposing factors of bicycle-associated injuries, a profile of the above studies will be presented according to study type, injury diagnosis and severity, causation, assessment of fault, seasonal and day/time distributions, helmet usage, socioeconomic considerations, and substance abuse, as appropriate. The following sections will provide a detailed review of each of the studies to be included in the analyses. The rationale for this selected approach, aside from providing a review of the relevant literature, was to provide a profile for the study groupings and calculation of effect sizes necessary for the analyses. However, for those seeking a succinct summary, one is furnished at the end of each major section.

Hospital Based Studies

Regional Injury Profiles

Population Specification with Age and Gender Patterns

Bicycle-associated Injuries and fatalities were predominated by males in all studies providing sex-specific accident data (Kronisch et al. 1996; Zavoski et al. 1995; Yelon et al. 1995; Li et al. 1995; Frank et al. 1995; Ashbaugh et al. 1995; Largo & Thacher-Renshaw 1993; Agran and Winn 1993; McKenna et al. 1991; Spaite, Murphy, Criss, Valenzuela, & Meislin 1991; Thompson et al. 1990; Nakayama et al. 1990; Thompson et al. 1989; Tucci & Barone et al. 1988; Selbst et al. 1987; Kraus et al. 1984; Annegers et al. 1980). This pattern was prevalent regardless of the age of the sample population. A series of studies reviewed hospital discharge data from sample populations of varying sizes, ranging from community hospitals to statewide injury surveillance systems, in the design of their studies (Yelon et al. 1995; Zavoski et al. 1995; Frank et al. 1995; Rosenberg et al. 1993; Largo & Thacher-Renshaw 1993; Vane et al. 1993; Gerhart 1991; McKenna et al. 1991; King et al. 1991; Nakayama et al. 1990; Mackersie et al. 1988; Tucci & Barone 1988; Runyan et al. 1985; Annegers et al. 1980).

In an attempt to determine factors that may have influenced either the bicycle accident itself, the injuries sustained as a result of the accident, or both, two groups of investigators conducted phone interviews, while three others designed a questionnaire for completion by all bicyclists injured, or by their families (Ernester & Gross 1982; Tucci & Barone 1988; Belongia et al. 1988; Selbst et al. 1987; Watts et al. 1986). Ernester and Gross (1982) performed the first of such studies being reviewed here. Emergency room records from Oklahoma Children's Memorial Hospital and Edmond Memorial Hospital, a suburban hospital, for all children who incurred bicycle-related injuries were reviewed from April through October, 1980 (Ernester and Gross, 1982). Families of the injured children were contacted by phone for a more detailed exploration of the bicycle accident. All children were less than 20 years of age. Bicycle injuries occurred most frequently in children aged 5-10 years (60%), followed by children aged 11-14 years (22%). Children less than 5 years accounted for only 5% of all injuries. Gender specific data was not provided by these investigators.

A few years later, Tucci and Barone (1988), reviewed the emergency room records of St. Vincent's Hospital and Medical Center in New York, from March 1984 to December 1984. Similarly, they too made an effort to contact all injured cyclists for a phone interview. One hundred seventy-two patients were involved in a bicycle-related accident, of whom 153 (89%) were bicyclists, and 19 (11%) were pedestrians reportedly involved in a bicycle-related accident. As expected, the number of males injured in bicycle-related accidents outnumbered those of females approximately 3.6 to 1 (78% versus 22%, respectively). The mean age of the bicyclists was 26.6 years, while the mean age of the pedestrians was 41.6 years. The variations in age groups and reported data, make comparisons with Ernester & Gross's (1982) study difficult. However, a comparable study was performed by Belongia et al. (1988), who retrospectively reviewed the emergency room records of three or four general hospitals in Madison Wisconsin from April 1 to October 1 during 1981-1983 and from April 1- July 31, 1984. Although, a major distinction between the study conducted by Tucci and Barone (1988) and Belongia et al. (1988) was that while the former sought to examine all bicycle-related injury patients, the latter sought to identify bicycle-related head injured patients only. Interestingly, the resulting sample population of both studies was fairly similar.

Belongia and colleagues documented 187 cases of bicycle-related head injuries during their period of study. The mean age of the patients was 27 years. Of the 187 cases, 79 (42%) of all injuries were sustained by those aged 18-22 years, followed by 51 (27%)

among those aged 23-27 years, and 22 (12%) of those aged 28-32 years. Male head injured cyclists dominated females 56% to 44%. However, Belongia and associates noted that the proportion of males and females sustaining less severe injuries (mild and moderate) were the same, but those experiencing severe and life-threatening injuries were comprised entirely of males.

Watts et al. (1986) evaluated all patients admitted to the emergency department of Boulder Community Hospital, Colorado, who sustained a bicycle-related injury. Each patient was also asked to complete a questionnaire requesting more detailed information that may potentially have contributed to their accident. The study took place from April 1, 1983 through September 30, 1983, as this time was identified as the primary cycling period in the region. A total of 253 patients incurred bicycle-related injuries. This accounted for approximately 0.5% of all admissions during that time frame (Watts et al. 1988). The patients ranged in age from 2 to 77 years, with a mean age of 22 years. Men comprised 66% of those cyclists injured, with women accounting for 34%. Important factors which were found to have contributed to the cycling accidents will be discussed in subsequent sections.

A study similar in design to Watts et al. (1986), but with a more focused age-specific sample population, was subsequently published by Selbst and associates (1987). The Children's Hospital of Philadelphia was the site of a study conducted by Selbst and colleagues (1987) between April first and October first of 1983. Selbst and colleagues (1987) sought to identify factors contributing to bicycle-related accidents through the assessment of all those receiving treatment for such injuries at their emergency department. In addition, they too requested all those injured, or their parents, to complete a comprehensive questionnaire revealing more details of the accident. All patients were less than 19 years of age, with a mean age of 8.7 years. Five hundred and twenty, or 10%, of all those receiving treatment in their emergency department sustained bicycle-related injuries. Eighty percent of the bicyclists injured were between the ages of 5 and 14 years. Injuries were noted to occur more frequently in males (72%) compared to females (28%).

A prospective assessment of an injury surveillance system comprised the sample utilized by Klauber and associates (1984). These authors sought to assess the epidemiology of head injuries in San Diego County, California during 1978. Data was collected prospectively by accessing the hospital discharge database from a group of hospitals in San Diego County, surveying emergency room admission diagnoses which were later confirmed, and examining coroner's records and death certificate data. Bicycle-related head injuries accounted for 5.6% of all head injuries and 1.6% of all fatal head injuries. Children aged 0-9 years appeared to be at highest risk of experiencing head injuries due to bicycle accidents. Evidence for this statement includes the highest proportion of age-specific bicycle accidents (11.8%) relative to injuries sustained from all mechanisms of injury within a given age group, together with the highest percentage of bicycle fatalities among those incurring bicycle-related head injuries (6.7%). Bicyclists aged 10-19 years registered 11.1% of all head injuries within the 10-19 age group, but accounted for 62% of all head injuries due to bicycle accidents.

Kraus and associates published a series of articles utilizing the same study population as Klauber and colleagues (1984), San Diego County, California, but differed, in that it was collected during 1981 (1984, 1986, 1987 & 1990). Three thousand three hundred fifty-eight physician confirmed brain injuries were documented, for an annual incidence rate of 180 per 100,000 population (Kraus et al. 1984). Among those, brain injuries due to bicycle-related accidents accounted for 251 (7.5%) of all brain injuries. Children aged 14 years or less experienced 153 (61%) of all bicycle-related brain injuries and 22% of brain injuries by all mechanisms for this age group (Kraus et al. 1987). In addition, this same age group was involved in 69% of the bicycle accidents not involving automobiles, and 45% of the bicycle collisions with automobiles that resulted in brain injuries (Kraus et al. 1987). Like the majority of studies, the incidence of brain injury due to bicycle-related accidents was greater in males than females, with males aged 5-14 years experiencing the highest incidence (Kraus et al. 1984). Furthermore, the rate for bicycle-related serious brain injury was noted to be three times higher for males compared to females (Kraus et al. 1987). In children 19 years or less, non-motor vehicle bicycle accidents accounted for 11% of all brain injuries and 13% of all male brain injuries, versus 8% of all female brain injuries (Kraus et al 1990). The delineation between brain injuries and head injuries being that brain injuries involved physical damage of the cranial contents resulting from a sudden change in the mechanical energy of the head, or caused neurological functional impairment of the victim.

San Diego County, California formed the sample population of yet another study conducted by Mackersie and associates (1988). Distinct from above studies, this group of researchers sought to evaluate the skeletal injuries in trauma patients. Data acquired from the Regional Trauma System between May 1985 and September 1987 constituted the subject population. All patients were 13 years of age or older, and presented with a depressed level of consciousness, designate as a Glasgow Coma Score of 10 or less on admission (Mackersie et al. 1988). A total of 10 bicycle-related trauma patients were identified. Three of the ten patients were noted to have "major skeletal injuries (MSI)." MSI's were defined as those injuries that were felt to be "life or limb threatening, or capable of producing major disability" (Mackersie et al. 1988, p. 1451). Although Mackersie and associates (1988) did not provide detailed accident characteristics or injury etiology by mechanism, they did report that injured bicyclists did not have an increased chance of sustaining MSI versus non-MSI. This was in contrast to pedestrian-MVA and motorcycle accidents, who were found to have a significantly increased chance of incurring MSI ($p < 0.05$) (Mackersie et al. 1988).

Similar to Mackersie and associates (1988), researchers in Colorado accessed data from the Colorado Spinal Cord Early Notification System, to present two sequential studies aimed at the evaluation of spinal cord injuries. Gerhart (1991) published the first manuscript in the series which included traumatic spinal cord injuries sustained from January 1, 1986 through December 31, 1989. Three hundred fifty-eight patients were identified, of which 6 were the result of bicycle-related accidents. The second manuscript, utilizing the same tracking system, was published by Rosenberg, Gerhart, and Whiteneck

(1993). This sample pool included all spinal cord injuries sustained between January 1, 1986 and June 6, 1991. A total of 10 bicycle-related accident victims were identified, thereby indicating that 4 additional bicycle-related accident victims incurred traumatic spinal cord injuries from January 1, 1990 through June 6, 1991. Only 2 of the 10 patients were reported to be involved in bicycle-automobile accidents, representing 0.4% of all non-occupational spinal cord injured patients. Although age, sex, injury severity and location were reported for occupational and non-occupational injuries, detailed information was not provided for the small sub-group of injured bicyclists.

The methodology of choice for a number of studies was the review of hospital discharge data (Annegers et al. 1980; Friede et al. 1985; Runyan et al. 1985; Nakayama et al. 1990; McKenna et al. 1991; King et al. 1991; Largo and Thacher-Renshaw 1993; Vane et al. 1993; Yelon et al. 1995; Frank et al. 1995; Zavoski et al. 1995). Annegers and associates (1980), assessed the incidence, causes and trends of head injury in Olmsted County, Minnesota from 1935 through 1974. They obtained the necessary data from a comprehensive medical records linkage system, associated with the Mayo Clinic in Rochester, Minnesota, that is used to study factors associated with many diseases and other conditions. Annegers and colleagues (1980) accessed this database to identify all cases of head trauma, one of which was bicycle-related head trauma. In their examination of the data, Annegers et al. (1980) noted that the age-adjusted rate of bicycle-related head injuries was 21 per 100,000 in males and 11 per 100,000 in females. Among those injured while riding a bicycle, children between the ages of 5-14 years were at greatest risk, with rates of 74 per 100,000 for males and 39 per 100,000 for females (Annegers et al. 1980). The number of head injuries sustained outside the 5-14 age group was reportedly minimal. However, Annegers and associates commented that although bicycle-related head injuries comprised 6.4% of all causes of head injury during the period of study, the severity of bicycle-related head injuries was most often mild.

Comparable to the medical records linkage system in Olmsted, Minnesota, Friede and associates (1985) utilized data provided by the Department of Public Health. Friede and associates (1985) obtained a sample of data from the Statewide Childhood Injury Prevention Program (SCIPP) operated by the Massachusetts Department of Public Health. The SCIPP surveillance system gathers data from 23 hospitals providing care to 14 Massachusetts cities and towns. The sample consisted of 25% of all bicycle-related injuries and 100% of all bicycle related mortalities sustained by children aged 0-19 years, from September 1979 to August 1982. Bicycle injuries numbered 573, which was equivalent to 87.8 injuries per 10,000 person-years. Males registered the highest proportions of injuries in all age groups, with boys aged 6-12 years being at highest risk, comprising 38% of all injuries and 52% of all male injuries. Like males, the age group 6-12 years represented the group at greatest risk for females, consisting of 16% of all injuries, but including 60% of all females injuries. No deaths were reported.

Analogous to Friede and associates (1985), Runyan and colleagues (1985) reviewed approximately 89% of the 1980 pediatric discharge data for the state of North Carolina. The subject population consisted of children less than 20 years of age. The highest bicycle-related death rates computed using age-specific census population were noted in children aged 10-14 years (0.20 per 10,000). However, the highest bicycle-related injury rate was documented as 6.6 per 10,000, and was found in the 5-9 year age group (Runyan et al. 1985). Gender-specific data was not provided. Comparably, Vane and associates (1993) examined the hospital discharge data for Vermont, between 1985 and 1990. Unlike the above studies however, Vane and colleagues (1993) evaluated a sample of the records for those patients aged 0-18 years only. Their sample reportedly represented 14.2% of all hospital admission for this age group over the period of interest (Vane et al. 1993). Injury rates per 10,000 population for nonmotor vehicle-cyclist injuries were 3.8 for males and 1.3 for females.

Similar to the above studies, both Frank and associates (1995) and Largo and Thacher-Renshaw (1993) examined in-patient data submitted to an injury surveillance system. Frank and associates (1995) accessed data from the Oregon Injury Registry during 1989. Although these researchers aimed to "review all bicycle crash-related injuries reported . . . to compare patterns of injury and other features in adults versus children and adolescents," they only reported detailed information on bicyclists who sustained neurologic injuries, which by definition were head and spinal cord injuries (p. 200). A total of 311 patients who had incurred a bicycle-related injury were abstracted. Of these patients, 122 (40%) were adults aged 21 years or older, and 189 (60%) were children less than 21 years. Largo and Thacher-Renshaw (1993) reviewed a sample of the in-patient discharge diagnoses submitted to the Office of Health Statistics in Rhode Island during

1990. The authors noted that males were more than three times likely to require hospitalization from bicycle-related injuries than females, with boys aged five to fourteen being at greatest risk. The increased susceptibility of this age group was noted in both males and females as this group of subjects reportedly included 2/3 of the injury population for both sexes. Agran and Winn (1993) united the methodology of Largo and Thacher-Renshaw (1993) and Friede and associates (1985) in their use of data from a large multi-hospital recording system, with Watts et al. (1986) and Selbst et al. (1987), in their seeking more detailed information from the families of injured children. Agran and Winn (1993) acquired data from a large multi-hospital monitoring system of pediatric trauma patients in Orange County, California. The monitoring system included 26.3% of the county's hospitals, and the coroner's office data. Among the hospitals, 75% of the county's trauma centers, the primary children's hospital and the university hospital were all included. Children aged 14 years and younger, who incurred their injuries solely as a result of a bicycle-motor vehicle collision comprised the subject population. The children entered one of the participating hospitals through the emergency department, from April 1987 to March 1989. A subsequent telephone interview with the parent or guardian of all injured bicyclists was performed. A total of 289 children injured in bicycle-motor vehicle collisions were reported. The age distribution of the subjects consisted of 2.1% aged 0-4 years, 31.8% aged 5-9 years and 66.1% aged 10-14 years. The majority of bicyclists were male (78.2%).

Comparably, Zavoski et al. (1995) reviewed hospital discharge data from 1987-

1991 and vital statistic data from 1987-1992 for Connecticut residents. Seventy-seven percent of all bicyclists hospitalized for related injuries were males. This propensity was consistent across all age groups. The most vulnerable age group differed for males and females. The 10-14 year age group sustained 32.1% of all male injuries and 25% of all female injuries. Conversely, the 5-9 year age group reportedly sustained the most injuries for females (30%), and accounted for 7% of all injuries (Zavoski et al. 1995). The male proclivity for bicycle-related injuries extended into bicycle-related head injuries and deaths as well (Zavoski et al. 1995; Annegers et al. 1980). Zavoski and colleagues noted that males in the 10-14 year age group incurred the highest bicycle-related head injuries at a rate of 31 per 100,000 of the Connecticut population. In addition, males aged 10-14 year not only incurred the highest bicycle-related death rates at 2.4 per 100,000, but also reportedly sustained the highest death rates from head injuries as a result of bicycle accidents.

A review of hospital discharge data remained the methodology of choice for the studies to follow. However, in contrast to the corresponding studies previous reviewed, these studies acquired their data from individual medical centers, rather than large surveillance systems (Boswell et al. 1996; Nakayama et al. 1990; King et al. 1991; McKenna et al. 1991; Yelon et al. 1995; Zavoski et al 1995). The Children's Hospital of Pittsburgh was site of the study performed by Nakayama and associates (1990). They reviewed hospital records from 1979 through 1986 for acquisition of the data. Three hundred seventy-two children, aged 2-15 years (median age = 9 years), who were admitted for a bicycle-related injury formed the subject population. Of those admitted, 232 (62.4%)

were males and 140 (37.6%) were females.

Like Nakayama et al. (1990), King and associates (1991) evaluated the pediatric discharge data of all children less than 16 years who were admitted to the Children's Hospital of Alabama from 1987-1988. A sub-sample of 45.5% of all discharge data for children under the age of 15 served as the sample. Because this study sought to evaluate all pediatric injuries and not just bicycle-related injuries, detailed reports of the latter injuries were not provided. However, the authors did note that bicycle-related injuries were the third most frequent cause of injuries (9.5%), behind falls (33%) and unintentional poisoning (13%). Furthermore, a statistically significant relationship between males and pedal cycle injury discharges was noted when compared to females (chi-square = 3.93, p-value = 0.48).

McKenna and associates (1991) reviewed the medical records of pediatric bicycle trauma patients admitted to the Children's Hospital and Medical Center in Cincinnati, Ohio, a tertiary children's care facility, over a five year period spanning from 1983-1987. Their subject population included patients admitted to the hospital for a bicycle-related trauma. Two hundred and one patients aged 3 to 16 years were ascertained, with a mean age of 10 years. Analogous to the above studies, 153/201 (76%) of the subjects were male (McKenna et al. 1991). Unlike McKenna et al. (1991), Yelon and associates (1995) retrospectively examined the medical records of bicycle trauma patients, of all ages, admitted to a New York hospital trauma service between January 1986 and December 1991. Their subject population ranged from 3-73 years of age, with a mean age of 21.3 years. Eighty-three percent of their subject population was reportedly male, versus 17% female.

Although Boswell and associates (1996) accessed hospital and emergence medical services data from two Georgia trauma centers, one of which was the Children's Memorial Medical Center, the authors sought to examine pediatric trauma mortality only. Mortality victims resulting from all mechanisms, ranged in age from 2 weeks to 14 years. Motor vehicle accidents predominated (31 of 69, 45%) followed by pedestrian-motor vehicle accidents (19 or 69, 27.5%), then bicycle accidents (5 of 69, 7%). Of the 5 bicycle-related mortalities, 4 (80%) mortalities resulted from collisions with a motor vehicle. Gender specific data was not provided.

Li and associates (1995) study, utilizing data from the National Pediatric Trauma Registry (NPTR), aptly serves as an aggregate for the above studies that focus on children. The NPTR is comprised of 62 trauma centers, 61 in the U.S. and 1 in Canada. Data procured for the years 1989 through 1992 formed the study population. A total of 2333 bicycle-related trauma patients were identified. Of the 2333, 1777 (76%) were male, and 559 (24%) were female. A positive relationship was noted between age and bicycle injury. The oldest children (10 - 14 years) in the registry sustained the majority of injuries (1114, 48%), followed by the 5 - 9 year old age group (1086, 46%), and the 0 - 4 year old age group (133, 6%).

A unique series of studies based on the data acquired from their case-control study in Seattle, Washington, were published by Thompson and colleagues (1989, 1990, 1990). Reportedly the data used for the case-control study was limited to those patients belonging to the Group Health Cooperative (GHC), a large group health maintenance organization, so that population-based rates could be calculated (1990). Population rates were based on the East and Central mid-year 1986 populations of the health maintenance organization. Injury rates were noticeably higher in males versus females for all age groups. Males aged 10-14 years were found to have the highest rate of bicycle injuries at 1260.9 per 100,000. The highest injury rate noted for females was 414.6 per 100,000, and was associated with the 5-9 year age group. Head injuries sustained from bicycle related accidents were also delimited by age and sex. Head injury rates were higher for males versus females for all age groups with the exception of the 25-44 age group, where the rates per 100,000 for males and females were 14.8 and 21.1 respectively. The 5-9 age group was found to be most susceptible to head injury regardless of sex; 414.7 per 100,000 for males and 147.1 per 100,000 for females. Overall, the head injury rate per 100,000 for all children aged 5-9 was 283.0, which accounted for 27% of all head injuries from bicycle-related accidents.

Unlike the above studies, Kronisch and colleagues (1996) reviewed the types of injuries sustained by competitive cyclists during a 5 day off-road bicycling race in California. A total of 3624 cyclists had 4027 individual starts, as racers were permitted to enter more than one racing event. Therefore, 4027 was used as the denominator in the calculation of various overall rates/percentages. Sixteen injured riders, 11 males and 5 females, were reported. Data was obtained by first-aide physicians located at the cite of each racing event. A physician associated with the study re-examined all cyclists who required hospital admission the day each was admitted to the hospital, to obtain more thorough injury information.

In contrast to the above studies, the remainder of studies to be presented in this section prospectively assessed various factors associated with bicycle-related hospital admissions. Each had a slightly different purpose, but all aimed to identify factors that contribute to the injuries sustained by bicyclists. An early study conducted by Walker and Raines (1982) followed an Appalachian community associated with a primary care center in rural West Virginia. Nonfatal accidents were documented during the five-year study period extending from January 1, 1976 through January 1, 1981. Bicycle injuries ranked 10th, for an overall percentage of 2.2%. Among those cyclists injured, males dominated with 56% versus 44% in females, with a male to female ratio of 1.3 to 1 (Walker & Raines 1982). The socioeconomic disparity between the subject population of Walker and Raines' (1982) study and most other studies in this review, may potentially explain the closer than normal injury proportions between males and females. This divergence from the typical overwhelming male predominance, may identify an important factor in the understanding of injuries in lower socioeconomic communities.

A similar study using a distinctly different subject population, was a subsequent study performed by Ashbaugh and associates (1995). Ashbaugh and associates (1995) also conducted a prospective study, but it was implemented at 10 major children's hospitals in Ohio during 1993. They reviewed various aspects of bicycle-related injuries. All patients were under the age of 16, and males exceeded females 73% to 27%.

Spaite and associates conducted two serial prospective studies at the University

Medical Center in Tucson, Arizona (1991, 1995). The first of these studies gathered information on all bicycle-related injuries seen at the emergency room or admitted to the University Medical Center in Tucson, Arizona from January 1986, to January 1989. An important distinction between this study and the above studies, is that the focus of this study was bicyclists whose injuries resulted from bicycle-motor vehicle collisions only. All other causes of bicycle-related injuries were not examined.

Spaite and colleagues (1991) found the Injury Severity Score (ISS) to be negatively correlated with both age and helmet use. Among patients with an ISS greater than 15, 44.6% were less than 18 years, versus 24.8% who were 18 years or older ($p < 0.005$). Similarly, among patients with an ISS greater than 15, 5.2% wore helmets at the time of their accidents, versus 47.0% who did not ($p < 0.0001$). As is common among all trauma patients, the preponderance of patients involved in bicycle-motor vehicle collisions were male. Although helmet users were more likely to be female 55.8%, versus male 35.5% ($p < 0.005$), when non-helmeted patients were evaluated separately, no significant difference was noted between males and females ($p < 0.851$) (Spaite et al. 1991).

In their second manuscript, Spaite and associates (1995) aimed to determine whether a relationship existed between bicycle-related injuries, alcohol consumption, injury severity, helmet use, and the expenditure of medical resources in the treatment of bicycle-related injuries. Data was again prospectively acquired from the University Medical Center in Tucson, Arizona, a level 1 trauma center, from January 1, 1991 through October 31, 1992. Subjects included all patients 18 years of age or older, that were seen in the

Emergency Department for a bicycle-related injury. Thus, the subjects comprising this study, and their earlier study, should not have overlapped.

A total of 389 injured bicyclists aged 18-71 years were identified, but helmet use was only available on 350 (90%) subjects. Therefore, the study group was limited to those 350 victims. Of the 350 adult cyclists, 248 (70.9%) were male and 102 (29.1%) were female. Subjects were subsequently separated into two groups, those with blood alcohol levels (BAL) > 0, and those with a BAL < 0, or absence of clinical evidence of alcohol consumption (Spaite et al. 1995). The first group of subjects, those with BAL > 0, consisted of 29 patients, of whom 22 (76%) were male, and 7 (24%) were female. The mean age of this group was 33 years (range = 18-42 years). Only 2 (6.9%) of these patients were wearing a helmet at their of their accident.

The remainder of the subjects formed group 2, those with a BAC < 0. Accordingly, this group included 321 patients (91.7% of the total study population), with a mean age of 29 years (range = 18-71 years). One Hundred and nine subjects (34%) of the subjects comprising this group were documented as having worn a helmet at the time of their accident.

<u>Injury and Mortality Summary Data</u>

Of the studies that focused on evaluation of bicycle-related injuries and fatalities requiring hospital treatment or admission, two studies reported the overall percentage of bicycle injuries per total hospitalizations at 0.5% and 10% (Watts et al. 1986 and Selbst et al. 1987, respectively). Other studies reported the rate associated with bicycle related injuries & fatalities (Annegers et al. 1980; Friede et al. 1985; Runyan et al. 1985; Thompson et al. 1990; Largo & Thacher-Renshaw 1993; Vane et al. 1993; Zavoski et al. 1995). Rates varied considerably depending upon the age and socioeconomic status of the subject population.

Hopkins et al. (1990) reported an observed death rate for child bicyclist mortality of 20.9 per 100,000 children, for children aged 1-16 years living in Ohio during 1979-1986. Further, Hopkins and colleagues report that those aged 12-16 years incurred the highest death rate of 11.5 per 100,000 children. Conversely, Friede et al. (1985) noted a death rate of 0.71 per 100,000 bicyclists in a sample of Massachusetts children aged 0-19 years. Similar to Friede et al., Runyan et al. (1985) reported a bicyclist death rate of 1.0 per 100,000 in North Carolina children aged 0-19 years during 1980, while Zavoski et al. (1995) documented a bicycle death rate of 0.25 per 100,000 for all Connecticut residents.

The overall bicycle related injury rate for the Group Health Cooperative (GHC) in Seattle, Washington for a one year period beginning December 1986, was 16.3 per 10,000, based on the mid-year 1986 population of the GHC. However, the authors failed to provide the denominator used in their calculation. The highest age-adjusted rate of 80.9 per 10,000 was noted in the 10-14 year age group (Thompson et al. 1990). No death rates for bicycle accidents were provided by Thompson et al. (1990). The bicycle-related injury rate for the 0-19 year age group in Thompson et al.'s study was 45 per 10,000. In comparison to Thompson et al. (1990), Friede et al. (1985) noted an overall bicycle-associated injury rate of 87.8 per 10,000 person-years for the same age group (0-19 years) from 1979-1981 in

Massachusetts children. Comparably, the highest bicycle injury hospitalization rates for Connecticut residents were reported for those aged 5-19 years (Zavoski et al. 1995). Zavoski et al. (1995) documented bicycle injury hospitalization rates of 3.11, 4.62 and 15.3 per 10,000 in children aged 5-9 years, 10-14 years , and 15-19 years, respectively. An overall injury hospitalization rate for all Connecticut cyclists was reported as 0.88 per 10,000. Another researcher, Vane et al. (1993), noted an overall bicycle related injury rate of 0.45 per 10,000 in Vermont children less than 19 years of age. In North Carolina, Runyan and associates (1985) reported that pedal-cycle injuries accounted for 3.3 per 10,000 population per year among children in North Carolina. The highest injury rate documented Runyan and associates was 6.6 per 10,000, which was recorded for children aged 5-9 years. In contrast to both , Thompson et al. (1990) and Runyan et al. (1985), Friede and associates (1985) reported that adolescents aged 13-19 years possessed the highest rate of bicycle-related injuries among Massachusetts children from 1979-1982 with a rate of 4.37 per 10,000 person-years.

The lower rates noted by Vane and colleagues (1993) may be attributed to Vermont's rural population as recognized by the United States Census and Population Bureau. The authors speculate that the percentage of minor pediatric hospital admissions resulting from traumatic injury being admitted to the hospital in this rural state, may have contributed to the lower rate. Furthermore, they assert that the expected survival rate for children matched by age and Injury Severity Score (ISS) in Vermont, is twice that of the National Pediatric Trauma Registry. Reasons for the discrepancy noted in the rates reported by Thompson et al. (1990) and Friede et al. (1985) may be attributed to the higher education level (67% possessing greater than high school education), and fewer number of minorities (91% caucasian) in Thompson and associates sample population. Thus, not only is Thompson and associates sample less representative of the population as a whole, but it also under represents those at greatest risk for injury -- minorities and those who are socioeconomically depressed. This postulate is supported by Largo & Thacher-Renshaw (1993) who reported injury rates for all cyclists according to socioeconomic status for Rhode Island in 1990. Largo & Thacher-Renshaw (1993) noted that the risk of bicycle related injury was greater in those residing in poverty and lower socioeconomic areas, than for those from middle socioeconomic areas; 16.3, 17.9 and 4.6 per 100,000 population, respectively.

The failure of some researchers to provide total population sample size either used, or required, to calculate rate data limited the number of independent comparisons that may have been made between studies (Annegers et al. 1980; Selbst et al. 1987; Thompson et al. 1990; Vane et al. 1993; Zavoski et al. 1995). While some investigators may feel it unnecessary to provide the data due to its availability in Vital Statistic and related documents, reporting relevant denominators would require little effort on part of those who already have the data, and have used it in their calculations. Furthermore, it would permit accurate re-calculation of the associated percentages and rates, while allowing independent investigators to reformat the data in a manner that is most conducive to their purpose.

Location and Type of Injury

The injury patterns reported among cyclists varied according to the subject population of interest, and the aims of the researcher. Neurological and orthopedic injuries appear to predominate in hospital-based studies (Frank et al. 1995; Yelon et al. 1995; Zavoski et al. 1995; Selbst et al. 1987; Ashbaugh et al 1995; Largo & Thacher-Renshaw 1993; King et al. 1991; McKenna et al. 1991; Nakayama et al 1990; Belongia et al. 1988; Tucci et al. 1988; Friede et al. 1985; Ernester & Gross 1982). Presumably, this is because the severity associated with these types of injuries often warrants medical attention.

Several studies documented orthopedic injuries as the most common type of inpatient morbidity, with lower extremity injuries being most prevalent (Kronisch et al. 1996; Yelon et al. 1995; Selbst et al. 1987; Friede et al. 1985; & Ernster & Gross et al. 1982). Although, Tucci & Barone (1986) found upper extremity injuries to prevail in their study. Musculoskeletal abrasions and contusions were found in a large percentage of all those injured, and most likely account for the largest percentage of first aid treatment (Ernster & Gross 1982; Tucci & Barone 1988; Watts et al. 1986; Nakayama et al. 1990; Kronisch et al. 1996). While head injuries appear to out-number all other types of injuries as the leading cause of bicyclist mortality, some studies have also documented them as the leading cause of morbidity (Zavoski et al. 1995; Ashbaugh et al. 1995; Largo & Thacher-Renshaw 1993; McKenna et al. 1991; King et al. 1991; Nakayama et al. 1990).

Annegers et al. (1980) reported that bicycle associated head injuries accounted for 6.4% of all head injuries in Olmsted County, Minnesota between 1935-1974; fourth behind automobile accidents (36.8%), falls (28.8%), and recreational accidents not inclusive of bicycling (9.4%). Similarly, King et al. (1991) found that 9.5% of all those admitted to the Children's Hospital of Alabama during 1987 and 1988 experienced bicycle related injuries; third behind falls (33%) and unintentional poisoning (13%). Most notably however, the bicyclists in this study experienced the highest percentage of closed head injuries (67.6%). Although, Largo & Thacher-Renshaw (1993) reported a slightly lower percentage, 2.3% of all hospitalizations attributable to bicycle accidents, head injuries accounted for the largest percentage of all bicycle injuries (39%). Furthermore, Largo & Thacher-Renshaw (1993) recognized that percentage was three and one-half times higher than the percentage of head injuries attributable to all other types of injuries in Rhode Island for a one year beginning October, 1989.

In their assessment of all pediatric trauma mortalities in two designated trauma centers in Georgia between January 1, 1987 and September 30, 1992, Boswell and associates (1996) reported a total of 5 bicycle-related deaths, 2 (40%) of which were attributable to head injury. Alternately, Westman & Morrow (1984) reviewed the emergency room records for a six month period beginning May 1983, at the Children's Hospital in Columbus, Ohio in an attempt to assess the nature of injuries sustained by moped riders. The design of their study used bicycle related injuries as the control group, which comprised the larger of the two samples in size. Westman and Morrow (1984) noted that 2.6% of all emergency room visits were bicycle-related visits, 17% of which required intensive care unit (ICU) or operating room services. The largest percentage of hospitalized bicycle injuries (63%) presented with neurologic injuries alone, whereas 20% presented with orthopedic injuries alone (Westman & Morrow 1984).

Although Frank and associates (1995) sought to review all bicycle-related injuries and mortalities documented in the Oregon Injury Registry during 1989, their manuscript provided detailed injury data on neurologic injuries only. A total of 311 bicycle-related injuries or mortalities were registered. Frank et al. (1995) noted that 27 (14%) of 189 children, and 13 (10%) of 122 adults sustained skull fractures, while 36 (19%) of all children and 32 (26%) of all adults incurred intracranial injuries. Concussions were recorded in 22 children and 5 adults. Aside from spinal cord injuries which were documented for only 1 child and 3 adults, other types of injuries were not discussed.

In review of those studies aimed at determining the epidemiological characteristics of head injuries, bicycle-related crashes overwhelmingly were a major cause especially in children (Ashbaugh et al. 1995; Jaffe et al. 1993; Nakayama et al. 1990; Belongia et al. 1988; Kraus et al. 1984). Klauber and associates (1981) assessed the rate of head trauma patients in San Diego, California in 1978. These researchers found an overall incidence of head trauma of 295 per 100,000, with the highest rates noted in "the late teenage years" (567 per 100,000), and the lowest rates noted in those less than five years of age (117 per 100,000). Altogether, bicycle related injuries accounted for 6% of all head injuries. More specifically, Klauber and associates (1981) reported that bicycle injuries were responsible for approximately one in five of all head injuries in the 5 to 14 age group, and were inconsequential for those less than 5 as well as for adults over the age of 30 years. Later, Kraus et al. (1984) reported that bicyclists accounted for 6% of all transportation-related brain injuries in San Diego, California during 1981; unchanged from that previously noted by Klauber and associates (1981).

Using the same sample population, San Diego, California, Kraus and colleagues published a series of articles each detailing a different aspect of the overall data. A detailed analysis of bicycle-related head injuries was published in 1987. Kraus and associates (1987) noted that 7% of all brain injuries in San Diego, California during 1981 resulted from bicycle accidents. Reportedly, 86% of all bicycle related head injuries were mild injuries. In comparison, 12% of all bicycle-related head injuries were moderate or severe injuries, and 2% were fatal injuries. In general, these percentages reportedly corresponded to an annual brain injury incidence rate for bicyclists of 13.5 per 100,000 people. More recently, Kraus and associates, published the incidence of brain injuries incurred by children and young adults aged 19 years or less (1990). Of the external causes of brain injury assessed by Kraus et al. (1990), 11% resulted from non-motor vehicle bicycle accidents, while 4% resulted from a bicycle-motor vehicle collision.

The severity distribution of bicycle-related head injury documented in the above studies, was later substantiated by Belongia and associates (1988) in their examination of bicycle-related head trauma in Madison, Wisconsin from 1981 through 1984. Belongia and associates noted that of the 187 bicycle-related head injuries recorded during their study period, 119 (64%) were minor, 62 (33%) were moderate, 3 (2%) were severe, and 3 (2%) were life threatening. For comparison purposes the same head injury severity classification used by Kraus and associates (1984) was utilized by Belongia and colleagues, with a slight modification in the "minor" injury category. Unlike Kraus et al. (1984), Belongia and associates classified concussions and skull fractures in the moderate severity category (Belongia et al. 1988).

More recently, Warren and associates (1995) found comparable results in their assessment of traumatic head injury in Alaska from 1991 through 1993. Warren and colleagues noted that bicycle related traumatic head injury accounted for 4.1% of all traumatic head injury diagnosed in Alaska. Thus, although head injuries are a well-recognized cause of hospitalizations from bicycle-related accidents, the resulting severity of those are most often mild. Moreover, of the bicycle-related head injuries serious enough to require hospital admission, concussions and other minor head injuries are often among those most commonly treated, ranging from 48% to 64% (Li et al. 1995; Zavoski et al. 1995; McKenna et al. 1991; Belongia et al. 1988; Friede et al. 1985; Annegers et al. 1980).

Unlike the above studies, Spaite and associates (1991) prospectively assessed the difference in injury severity among helmeted and non-helmeted cyclists injured in a bicycle-motor vehicle collision, and seeking treatment at a level one trauma center to Tucson, Arizona. This population constituted 33% of all bicycle-related injuries seen at this trauma center. Accordingly, two-thirds of the bicyclists sustaining injuries severe enough to require treatment at a level one trauma center, were included in this study. Extremity injuries accounted for approximately 84.5% of all injuries. In comparison, head injuries comprised 13.4% of all patient injuries. The mean injury severity score (ISS) of all study patients was 12.2. More specifically, the mean ISS score among helmeted cyclists was 3.8, while that of non-helmeted cyclists was 18.0. Severe ISS scores, defined as a score greater than 15, were incurred by 29.9% of all study patients. Among those patients, 7.1% were wearing a helmet at the time of the accident. In contrast, of the 70.1% of patients with an ISS score < 15, 55.3% were wearing a helmet at the time of the accident ($p < 0.0001$). Overall study mortality was 3.9%. 72.7% (8/11) of all fatalities had sustained a major head trauma (subdural hematoma, epidural hematoma, or basilar skull fracture), with 62.5% (5/8) of head injuries identified as the primary cause of death. Non-helmeted cyclists comprised 22% of the head injured patients. Furthermore, none of the patients who sustained a subdural hematoma or a basilar skull fracture had been wearing a helmet at the time of the collision.

Utilizing data from the same level 1 trauma center, but not inclusive of the same time period, Spaite and associates (1995), conducted another prospective study with the aim of identifying the role alcohol consumption plays in bicycle injuries. They divided the subjects into two groups, those with BAL's > 0 (Group 1), and those with BAL's < 0 and with no clinical evidence of alcohol consumption (Group 2). The type, severity, and helmet use differed for both groups. Group 1 subjects (n=29) had a higher mean ISS score (10.3), were more likely to have had a major head injury, AIS ≥ 3, (17%), and were less likely to have been wearing a helmet at the time of their accident (2/29, 6.9%). In contrast, subjects in group 2 registered a lower mean ISS score (3.3), were less likely to have sustained a major head injury (2.2%), and were more likely to have worn a helmet at the time of their accident (109/321, 34%). The corresponding comparative significance values for these estimates were, p = 0.0001 (ISS), p = 0.0015 (major head injury) and p = 0.0004 (helmet use).

As a complement to the above studies, Li and associates (1995) accessed data from the National Pediatric Trauma Registry (NPTR). Recall that this group of researchers evaluated data from the NPTR for the years 1989 through 1992. A total of 2333 bicycle-related trauma patients were identified. Of the 2333, 1777 (76%) were male, and 559 (24%) were female. Head injury was the primary diagnosis in 44% (1026/2333) of all patients, although 54% (1252/2333) of all patients sustained a head injury. Concussions were the most prevalent form of head injury sustained (604/1252, 49%). Skull fractures (299/1252, 24%), intracranial hemorrhage (85/1252, 7%), and cerebral lacerations and contusions (59/1252, 5%) constituted the other major head diagnoses sustained by the injured child cyclists. Orthopedic injuries, namely fractures, were present in 43% (1003/2333) of all patients. Neck fractures were the most common (130/1003, 13%), followed by fractures of the humerus/radius/ulna (110/1003, 11%), facial fractures (100/1003, 10%), and femur fractures (90/1003, 9%). Notably, the authors report five important findings: 1.) 83% of all head injured patients also incurred other injuries, particularly, neck and limb injuries, 2.) only 30% of the entire subject population sustained only one injury, indicating the prevalence of multiple injuries among injured child cyclists, 3.) although boys outnumbered girls approximately 3 to 1 (boys = 1774, girls = 559), the percentage of each sustaining a head injury was equivalent (boys = 950 (54%), girls = 302

(54%), 4.) the positive relationship between age and injury extended from all injuries to head injury, with children aged 10-14 years sustaining the majority of head injuries (637/1114, 57.2%), followed by children aged 5 - 9 years (551/1086, 50.7%) and 0 - 4 years of age (64/133, 48.1%), and 5.) 73.3% of the patients with a pre-existing mental disorder (N = 60) incurred a head injury, versus 53.2% of those children with no mental disorder (N = 2273), exhibiting the effect of mental disorders, including attention deficit and neurohypophysis. A multivariate logistic regression analysis to estimate the presence of head injury among pediatric trauma patients aged 0-14 years of age, revealed that bicyclists with a pre-existing mental disorder were 2.4 times more likely to sustain a head injury in a bicycle collision, than those with no mental disorder ($p < 0.01$).

Competitive cyclists represented another study population that was different from the recreational cyclists previously reviewed. In their examination of bicycle injuries sustained during a 5 day multi-component competition, Kronisch and associated (1996) noted that of the 4027 total racing starts, 44 injuries were documented for 16 injured cyclists. The largest percentage of injury types were abrasions, lacerations and contusions, which comprised 32 of the 44 injuries (73%). Orthopedic injuries (5 fractures, 1 dislocation, and 1 strain) prevailed (16%), followed by concussions (4/44, or 9%), and one documented puncture wound (1/44, 2%).

While the same staggering proportions of severe morbidity and mortality are not experienced by bicyclists as compared to motor vehicle operators and passengers, nor are they equivalent to those sustained from falls in children, they do account for a large number of potentially preventable accidents, especially in children. It is because of this that medical professionals, researchers and public health care workers are attempting to formulate resourceful efforts to reduce the number of severe morbidity and mortality cases associated with bicycle-related accidents. In order to accomplish this goal an effort must be made to formulate a strategy that will benefit those at highest risk, rather than merely placing limitations on those who already are restricted by the confines placed upon them by socioeconomic circumstances. Furthermore, it is essential that any mandates effecting the community at large, be based upon data that is representative of the target community, and be supported by quality research.

Race and Socioeconomic Considerations

The majority of studies either did not report race or socioeconomic information, or only reported information not specific to the population of interest, namely bicyclists (Zavoski et al. 1995; Yelon et al. 1995; Schneidt et al. 1995; Schiller et al. 1995; Warren et al. 1995; Li and Baker 1995; Hawley et al. 1995; Frank et al. 1995; Rosenberg et al. 1993; Cowan et al. 1993; Jaffe et al. 1993; King 1991; Gerhart 1991; Thompson et al. 1990; Nakayama et al. 1990; Hopkins et al. 1990; Wasserman et al. 1988; McLennan et al. 1988; Mackersie et al. 1988; Belongia et al. 1988; Kiburz et al 1986; Watts et al. 1986; Friede et al. 1985; Whitman et al. 1984; Gallagher et al. 1984; Fife et al. 1983; Walker and Raines 1982; Ernster and Gross 1982; Annegers et al. 1980; Halek et al. 1971). Of those studies which reported racial information, disparities were prominent (Ashbaugh et al. 1995; Warren et al. 1995; King 1991; Whitman et al. 1984). Likewise, discrepancies were also found among the various socioeconomic divisions (Ashbaugh et al. 1995; Largo and Thacher-Renshaw 1993; King 1991; Kraus et al. 1986) Ashbaugh and colleagues (1995) noted that their sample population included 75% whites and 23% blacks. The median level of education attained for each parent was 12 years. Among those families that willingly disclosed financial information, 39% made less than $10,000 per year, 13% made between $10,000-$19,000 per year, 37% made between $20,000- $50,000 per year, and 11% made over $50,000 per year; thereby suggesting a prevalence of bicycle-related injuries in lower income families. The preponderance of bicycle injuries in lower income and poverty areas was more salient in Largo & Thacher-Renshaw's study (1993). These researchers indicated that hospitalizations for bicycle-related injuries in Rhode Island according to census tracts, revealed that those living in poverty and low income areas possessed injury rates of 16.3 and 17.9 per 100,000 population, respectively. In comparison, those living in middle socioeconomic areas were noted to have an injury rate of 4.6 per 100,000 population. This difference was reported to be significantly different ($p < 0.001$).

In their review of hospital discharge data for children injured by all mechanisms at the Children's hospital of Alabama, King (1991) noted that nonwhite boys had the highest discharge rate (127.5 per 10,000 population) of all injured children. White boys followed with a rate of 83.5, non-white girls a rate of 63.7, and lastly white girls with a rate of 48.4. All rates were reported per 10,000 population, and were adjusted for an overall system sensitivity value of 45.5% (King 1991). Gender-race specific bicycle accidents revealed that boys experienced a higher percentage of bicycle injuries than girls, for both white and non-white children: white boys (11.2%), white girls (9.8%), nonwhite boys (10.3%) and non-white girls (4.3%). Although caucasian children were found to have a higher rate of bicycle accidents than nonwhite children, rates between white and non-white boys were fairly similar. Accordingly, King (1991) commented that socioeconomic differences may have contributed to the higher overall injury rates noted in his study, in comparison to those reported by other studies, due to the greater impoverished population living in Alabama. This explanation gained further support by Largo and Thacher-Renshaw in their examination of bicycle injuries in Rhode Island, as noted above. Whether this increase is due to an under-estimate of the sensitivity value used by King (1991), an increase incidence of the number of injuries sustained by non-whites, or a greater non-white population serviced by the hospital, it emphasizes the need for educational safety programs in minority communities.

A distinctive study conducted by Whitman and associates (1984) sought to evaluate the traumatic head injury experiences of two socioeconomic communities in the Chicago area. The first area was comprised of an inner city black community that was economically depressed (96% black and 3% white, 1% other). The second area involved the more affluent suburban community of Evanston, Illinois (75% white, 21% black, 4% other). However, it is important to note that among the blacks residing in the Evanston area, 47% were living in the 5 poorest census tracts in Evanston. In addition, discordant age and race-adjusted incidence rates were found between the various populations under study. The incidence rates of head trauma per 100,000 population for each of the sample populations were 403 per 100,000 for inner city blacks, 394 for Evanston blacks, versus 196 per 100,000 population for Evanston whites. Detailed bicycle-related head injury data was not provided, as the aim of this study was to contrast the etiology of all causes of head injuries in the two separate communities. However, it was reported that head trauma due to bicycle accidents was experienced by 1% (6 of 617) of inner city blacks, 3% (2 of 62) of Evanston black, and 7% (7 of 103) of Evanston whites; thereby suggesting relatively equivalent proportions among blacks and whites.

The cause specific nature of head injuries differed for both communities. Evanston blacks and whites sustained the greatest number of head injuries from motor vehicle accidents (32% and 39% respectively). Conversely, interpersonal attacks lead the cause distribution of head injuries for inner city blacks at 40%. These two cause-specific categories reversed as the second leading cause of head injuries among blacks; 31% motor vehicle related head trauma for inner city blacks, and 26% of head injuries resulting interpersonal attacks for Evanston blacks. The second and third leading causes of head trauma registered for Evanston whites were falls (31%) and recreational activities (14%). In an ancillary comment, Whitman and associates (1984) remarked that motor vehicle safety measures may provide little preventative assistance for a community whose streets and structural design are in need of as much support as the people residing there. Should this be true, it may very well apply to bicycle-related safety gear as well. Therefore, prior to mandating protective head gear for all members of our society, maybe we ought to evaluate the needs of all its members first, rather than imposing limitations on communities who are already forced to battle the whims of violence.

In contrast to the studies performed by King (1991) and Whitman and associates (1984), Thompson and associates (1990) published a series of studies that examined the incidence of bicycle-related injuries in a primarily white (91%) population, where 67% of the constituents had attained higher than a high school education. The remaining 9% of the ethnic composition consisted of 3% Blacks, 4% Asian/Pacific Islander, and 2 percent other. While the economic structure of this sample population was not discussed, a reasonable assumption based on the acquired educational level of the cases, may be that Thompson et al.'s subject population was not indicative of the American population as a whole. Rather, Thompson and associates' study sample appeared to over-represent the better educated American public, and under-represent minorities and lower income and poverty communities. Because these differences have been shown to be key factors in injury surveillance, caution should be used in making general inferences from these studies (Thompson et al. 1989, 1990, 1990).

Conversely, one study, in the series of studies published by Kraus and associates (1986) using the data collected during 1981 from San Diego County, California, focused on the socioeconomic variations in the incidence of severe and fatal head injuries. Kraus et al. (1986) found that severe brain injury from bicycle-automobile accidents were evenly distributed according to median family income. A rate of 1.0 per 100,000 population (based on the 1980 San Diego County, California census population) was recorded for each of the following median family income categories: less than $15,000, $15,000 - $19,999, and $20,000 and over. These incidence rates were not adjusted for age, sex, or race. However, the original study published by Kraus and associates (1984) noted that of the 2160 head injured patients from all causes, with known race or ethnicity, 79% were White, 12% Hispanic, 6% Black, and 2% Asian or other. With these overall proportions in mind, 86.6% of the 823 patients sustaining severe or fatal brain injuries from all causes (as reported in the 1986 study) were white, 4.7% were black, 6.2% were hispanic, and 2.4% were American Indian/Asian (Kraus et al. 1986). Moreover, the rate of serious brain injuries per 100,000 persons by median family income was highest for persons in the lowest median family income category (< $15,000) for whites (65), and American Indian/Asians (34), approximately equal to the $15,000 - $19,999 category in blacks (41 versus 42 per 100,000 persons), and unexpectedly increased from 31 to 39 to 56 per 100,000 persons for Hispanics as the median family income increased across categories. Furthermore, among those seriously injured from all causes, including those with bicycle-related brain injuries, those in the high median family income category were found to have a slightly better outcome than those in the low and middle median family income categories (Kraus et al. 1986).

Finally, in their assessment of traumatic head injury in Alaska from 1991-1993, Warren and colleagues (1995) noted that Native Alaskan patients were approximately 2.5 times more likely to incur a bicycle-related head injury than non-Native Alaskans.

Time of Day/Week and Seasonal Variations

Bicycle accidents were most prevalent during the summer months (Yelon et al. 1995; Largo & Thacher-Renshaw 1993; Thompson et al. 1990; Klauber et al. 1981; Annegers et al. 1980). Thompson and associates (1990) documented that 42% of the injuries sustained by bicycle riders took place during the months April through June, followed closely by those injured during the later summer months, July through August at 35.3%. Similar to Thompson, Agran and Winn (1993) noted that bicycle-motor vehicle collisions occurred mostly during the Spring (28%) and Summer (27%) months. Largo & Thacher-Renshaw (1993) confirmed the above findings, noting that bicycle-related injury admissions were most frequent from May through September, with nearly 25% occurring in August alone. Similarly, Yelon and associates documented that 45% of the bicycle accidents they reviewed, occurred from June through August. The increase in bicycle accidents during Spring reported by both Thompson and associates (1991) and Agran and Winn (1993) may be partially attributed to their implementation on the West Coast, in comparison to the studies conducted by Largo and Thacher-Renshaw (1993) and Yelon and colleagues (1995), which took place in Rhode Island and New York, respectively.

Bicycle accidents most frequently occurred during daylight hours (Ernster & Gross 1982; Watts et al. 1986; Selbst et al. 1987; Tucci and Barone 1988; Belongia et al. 1988; Kraus et al. 1990; Agran and Winn 1991; Yelon et al. 1995; Ashbaugh et al. 1995). In consideration of the role "time of day" may have contributed to the occurrence of the documented bicycle accidents, Watts and associates (1986) indicated that the majority of accidents occurred between 9 AM and 4 PM (40%), followed by 23% between 4 PM and 6 PM. The remainder of the accidents happened from 6 AM to 9 AM (5%) and 6 PM to 6 AM (32%). Therefore, approximately 22% of all bicycle accidents reviewed by Watts and associates (1986) occurred during low-light hours. Similarly, Selbst and colleagues registered the majority of bicycle injury accidents between 4-8 PM (58%), with 29% of the injuries occurring prior to 4 PM, and 13% after 8 PM. Using slightly different time groupings, Agran and Winn (1993) noted that the majority of accidents they reviewed occurred between the hours of 3-6 PM (42.5%). This temporal characteristic was prevalent even after the bicyclists' data were separated into two categories, "purposeful trips" (53/144, or 37%) "playing" (70/99, or 71%). In addition, Agran and Winn (1993) reported that bicycle-motor vehicle collisions were more prevalent on weekdays (75.8%). However, a significant difference was found among those riders experiencing a weekday collision while playing (67%) versus riders involved in a bicycle-automobile collision while on a purposeful trip (82%) ($p < 0.002$).

Providing fewer groupings, Yelon and associates (1995) noted that the afternoon and early evening hours from 1-9 PM represented the time of day during which cyclists were at greatest risk, accounting for 60% of all bicycle accidents. Although, Tucci and Barone did not provide an hourly breakdown of when bicycle accidents occurred, they did note, of the 41 (27%) bicyclist and pedestrian patients interviewed, 39 (76.5%) were injured during daylight hours. Recognition of the prevalence of bicycle accidents during daylight hours is not a new phenomenon. Ernster and Gross (1982) performed a population specific study that identified this pattern. Ernster and Gross (1982) documented that 87% of children's bicycle accidents reviewed at two major hospitals in Oklahoma occurred during afternoon and evening hours, versus 3% at night. Correspondingly, bicycle accidents requiring medical attention also occurred most frequently during daylight hours (92%), and on the weekend (46%) in the children seeking treatment in Ohio (Ashbaugh et al. 1995). Similarly, Thompson and associates (1990) noted an overall percentage of weekend bicycle accidents of 41%.

Weather Conditions

Adverse weather conditions were not found to contribute to the majority of accidents reviewed by Selbst and associates (1987) nor Ashbaugh and colleagues (1995). Selbst and associates reported that 96% of the bicycle accidents occurred on clear days, compared to only 3% on rainy days. Comparably, Ashbaugh and colleagues noted that 96% of the accidents sustained by the children in their study happened on dry roads. Tucci and Barone's (1988) findings concurred with that of Selbst and associates, and Ashbaugh and colleagues. Tucci and Barone reported that among the 51 injured bicyclists and pedestrians interviewed post-accident, 41 (27%) of whom were injured bicyclists, 49 (96%) reported that their accident occurred on a clear day, versus 1 (2%) who noted the accident occurred on a rainy day, and 1 (2%) who could not recall the weather conditions at the time of the accident. Similarly, among the sub-sample of bicycle-related head injuries completing the post-accident questionnaire in the study conducted by Belongia and associates (1988), 79 of 100 patients (79%) confirmed that their accident happened during daylight hours, and on a clear day. Thus, adverse weather conditions do not appear to be a major contributing factor in those studies that documented its potential role.

Location and Collision Type

The location of bicycle accidents, and the type of collisions experienced by them, typically relates to the type and severity of the injuries sustained by bicyclists. Accordingly, a number of researchers examined these issues. The majority of investigators separated collision information into motor-vehicle and non-motor vehicle involvement (Zavoski et al., Yelon et al., Li et al. 1995; Frank et al. 1995; Ashbaugh et al. 1995; Largo and Thacher-Renshaw 1993; Agran and Winn 1993; Tucci and Barone 1988; Belongia et al. 1988; Selbst et al. 1987; Kraus et al. 1987). One of the earlier studies, but most frequently cited studies associated with bicycle-related injuries, is that conducted by Friede and associates (1985). Friede and associates noted collisions with motor-vehicles were the primary cause of bicycle fatalities (93.7%). Although, the percentage of cyclists requiring hospital admission following a collision with a motor vehicle was substantially less (26.8%) when considered among all cyclists requiring hospital admission (6%). This corresponded to a relative risk of hospitalization following a bicycle accident of 5.62 for automobile accidents, in comparison to all other types of accidents. Thus, Friede and associates (1985) warned that while bicycle-automobile accidents accounted for only a small percentage of accidents in their study, they caused the majority of the fatalities.

Interestingly, those studies whose subject population consisted of bicycle accident victims who sustained a head injury found comparable results. Kraus et al. (1984, 1987) documented that of the 251 bicycle-associated brain injuries recorded in San Diego County, California in 1981, 83 (33%) involved collisions with motor vehicles, versus 168 (67%) not involving motor vehicles (Kraus et al. 1987). Nevertheless, Kraus et al. (1987) commented that bicyclists sustaining brain injuries due to collisions with motor vehicles, often experienced more severe injuries, required longer hospitalizations, and resulted in less favorable outcomes. Specifically, 15% of the bicyclist-motor vehicle collisions were discharged with a Glasgow Outcome Scale score of moderate disability to death, versus 85% discharged with a good outcome. In comparison, all brain injured bicyclists due to non-motor vehicle accidents were discharged with a good recovery score on the Glasgow Outcome Scale (Kraus et al. 1987).

Belongia and associates (1988) noted that falls accounted for the greatest number of both minor (29%) and moderate/life-threatening (32%) bicycle-related head injuries. Bicycle-motor vehicle collisions accounted for 26% and 19% of minor and moderate/life-threatening injuries due to bicycle accidents, respectively (Belongia et al. 1988). Furthermore, bicyclist collisions with a fixed object accounted for 17% of the minor accidents, but 24% of the moderate/life-threatening accidents -- more so than those noted between bicycle and automobiles (Belongia et al. 1988).

The prevalence of non-motor vehicle collisions as the dominant cause of bicycle-related injuries is not an isolated or new phenomenon. Selbst and associates (1987) documented bicycle-motor vehicle collisions resulted in 17% of all injuries incurred by cyclists. These researchers further examined the road conditions at the time of the accident.

Environmental hazards were registered as the cause of the accident 7% of the time (Selbst et al. 1987). Poor road conditions were reportedly responsible for the bicycle accident in 36% of the cases; significant bumps in the road (14%), potholes (5%), gravel (5%), and other miscellaneous complaints (12%). Nonetheless, road problems were not considered to be a contributing factor in the majority of the bicycle accidents (64%) (Selbst et al. 1987).

Unlike the majority of studies, Tucci and Barone (1988) examined urban adult cycling accidents. However, results did not differ much from other studies. Tucci and Barone (1988) reported that among the 27% of injured bicyclists interviewed, 27.5% had a collision with a moving motor-vehicle, 25.5% fell from their bicycle, 27.5% had a collision with another bicyclist, and 19.5% had reported miscellaneous causes. Furthermore, 92.2% of those interviewed noted that the accident occurred on a paved street (Tucci and Barone 1988). These findings were similar to those reported by Watts and associates (1986), who documented that 49% of the cyclists injured were involved in an collision with a motor vehicle. Of the bicycle-automobile collisions examined by Halek and colleagues (1980), 90% occurred at intersections, and less than 4% were found to be the result of a motorist over-taking the bicyclist.

Thus, it appears that the preponderance of the studies were in agreement with one another, and additional studies continued to provide similar results (Friede et al. 1985; Kraus et al. 1987; Belongia et al. 1988; Selbst et al. 1987; Tucci and Barone 1988). Both McKenna and associates (1991) and King et al. (1991) found that bicycle collisions with motor vehicles were directly responsible for only (2%) and (29.4%) of all injuries to bicyclists, respectively. Frank et al. (1995) noted that 188 (60%) of all injured bicyclists included in the Oregon Injury Registry during 1989, were involved in a non-motor vehicle accident, versus 106 (34%) who sustained their injuries as a result of a bicycle-motor vehicle collision.

Comparable to Friede and associates (1985), Frank and colleagues (1995) revealed that collisions with motor-vehicles were the primary cause of both adult and child bicycling fatalities. Nine of ten (90%) of all adult bicycling fatalities resulted from collisions with a motor-vehicle, with the only other adult bicycling fatality resulting from a bicyclist's collision with a train. Similarly, all 5 child bicycle related deaths were the product of bicycle-motor vehicle collisions.

Analogous to Belongia and associates (1988), Ashbaugh and colleagues (1995) noted that bicyclist injuries were most often the result of a fall (56%) rather than from any type of accident. Falls were most prevalent in children 10 years of age or older (64%), while bicyclists aged 5-9 years were most frequently involved in collisions with another vehicle (57%). Fifty-eight percent of the accidents occurred when children were riding in groups, and were riding for recreational purposes (60%), as opposed to an intentional purpose, such as going to school (Ashbaugh et al. 1995). Bicycle accidents in suburban communities were slightly more frequent (46%) than those in urban communities (42%), and least common in rural areas (12%) (Ashbaugh et al. 1995). Finally, Ashbaugh and associates (1995) noted that 75% of the accidents occurred within ½ mile of the child's home.

Further evidence for the prevalence of non-motor vehicle causes of bicycle related injuries, in comparison to motor-vehicle related bicycle injuries, was provided by Largo and Thacher-Renshaw (1993). Largo and Thacher-Renshaw (1993) documented that although fatal bicycle accidents most often resulted from collisions with motor vehicles, the majority of bicycle accidents (80%) did not involve a collision with a motor vehicle. Similarly, Zavoski and associates (1995) noted that approximately 33% of bicycle injury hospitalizations and 75% of bicycle injury deaths were the result of bicycle-motor vehicle collisions. Further, the rate of bicycle-nonmotor vehicle accidents was found to be greater than that for bicycle-motor vehicle accidents in Connecticut towns of all sizes. While the hospitalization rate for collisions between bicyclists and nonmotor-vehicles were higher than those between bicyclists and motor-vehicles, the severity of the injuries sustained in bicycle-motor vehicle collisions was greater, as evidence by the longer mean length of stay for bicycle related-head injured patients involved in collisions with motor-vehicles (Zavoski et al. 1995). Like Tucci and Barone (1988), Yelon and associates (1995) categorized the types of collisions noted in their sample population into three major categories: falls from a bicycle, bicycle versus motor-vehicle, or bicycle versus bicycle. The majority of bicyclist injuries were the result of bicycle-motor vehicle collisions (44 or 52.3%), followed by falls from a bicycle (36 or 42.8%), and finally bicyclists colliding with other bicyclists (4 or 4.7%).

Data from the National Pediatric Trauma Registry (NPTR) encompassing the years 1989-1992, supports the majority of the above researchers. Li and associates (1995) examined the data from this registry, and reported that the majority of children incurring a bicycle-related injury, had done so from a non-motor vehicle collision (1174/2333, 50%). In comparison, 48% (1123/2333) of the children sustained their injuries from a collision with motor vehicle, and 2% (36/2333) from a collision with another bicyclist. Interestingly however, Li and associates (1995) revealed that collisions with another bicyclist resulted in the largest percentage of head injuries (23/36, 64%). Of the 1123 bicyclists injured from a collision with a motor vehicle, 623 (55.5%) sustained a head injury -- a proportion that was not significantly different from those bicyclists who incurred a head injury from non-motor vehicle collisions (606/1174, 52%). In addition, road accidents (1837/2333) were more prevalent than accidents in residential areas (251/2333) and accidents in all other areas (245/2333). Similarly, the percentage of head injuries sustained by scene of injury were also more common among children who incurred injuries from road accidents (1032/1837, 56%). Forty-nine percent of the patients whose injuries were incurred while cycling in "other" areas (non-residential and non-road areas) sustained head injuries (120/245), with cyclists injured in residential areas incurring the fewest percentage of head injuries (100/251, 40%).

Distinctly different from all other studies reviewed in this section, Agran and Winn (1993) examined the circumstances surrounding only those bicyclists injured in a collision with a motor vehicle. The largest percentage of collisions occurred as children were crossing an intersection (41.8%). This collision location was more prevalent for children known to be on a purposeful trip (53%), compared to children who were reportedly just playing as they rode their bicycles (27%). In contrast, among children who were playing, 36% were more likely to collide with an automobile while crossing midblock, versus 15% of the children on a purposeful trip. Most collisions occurred during periods of light traffic density (56.9%), and on two-way single lane roads. However, when assessed according to the reason for riding, the type of street varied. Eighty-two percent of children who were reportedly just playing on their bicycles, were injured while riding on a two-way single lane street, compared to 42% of children riding their bicycles for an intended purpose. In contrast, 58% of the children riding their bicycle for a purposeful trip reportedly collided with an automobile on a multilane road, versus 18% of the children who were playing on their bicycles. Unlike older teenagers and adults who have been noted to collided with motorists making a left turn, Agran and Winn (1993) found that the majority of children (66%) collided with motorists who were driving straight. Collisions with motorists driving straight were also more prevalent among children who were playing (80%), rather than among those on purposeful trips (56%). Side impacts between the bicycle and motor vehicle were most frequent, accounting for 71.1% of all collisions, 76% of collisions among those who were playing, and 68% of the collisions incurred by children who were on a purposeful trip at the time of their accident.

The cause of injuries experienced by competitive off-road cyclists, expectedly differed from the above reports. Because Kronisch and colleagues (1996) documented the causes of bicycle related accidents during an off-road racing event, motor vehicle involvement was not a possibility. Rather, the mechanism of the injuries included, mechanical problems (2, 12.5%), loss of control (5, 31.25%), collision with another rider (6, 37.5%), collision with an object (1, 6.25%) and loss of traction (2, 12.5%). Interestingly however, of the cyclists who did sustain an injury, racers classified as Pro/Elite riders comprised the largest percentage of injured cyclists (9 of 16, 56%), in comparison to amateur riders (7 or 16, 44%). However, due to a lack of expertise in the area of competitive cycling, this author does not feel qualified to make any additional inferences related to this finding. The reason for this is the author's lack of knowledge concerning the difficulty level and expertise required to participate in the various racing categories; namely, the downhill, cross country, eliminator, and dual slalom events. Possibly, the different types of competitions may require more advanced skills than others, while simultaneously being more dangerous.

Assignment of Fault

Age emerged as a crucial factor in the assignment of fault in the studies documenting its role in bicycle-related accidents. The younger the cyclist, the more likely reckless riding practices or failure to follow traffic rules, precipitated the bicycle accident (Ernster and Gross 1982; Selbst et al. 1987; McKenna et al. 1991; Ashbaugh et al. 1995). Cyclist error was the leading cause of injuries in a study conducted by Selbst and associates (1987). Selbst and associates found that in 45% of the bicyclists injured in their study, loss of control of one's bicycle was documented as the cause of the injury (Selbst et al. 1987).

Additionally, over one-third of the children injured while riding their bicycles, admitted that they sustained their injuries as a result of reckless riding at the time of the accident; i.e., riding too fast or performing tricks and stunts on their bicycles (Selbst et al. 1987). Reckless riding behavior was also designated as a precipitating factor in a large percentage of the cases reviewed by Ernster & Gross (1982). Speeding (27%) and "doing tricks" (19%) were two of the leading causes of the bicycling accidents (Ernster and Gross 1982).

Failure to follow traffic guidelines were the principal cause of the bicycle accidents in the studies conducted by McKenna and associates (1991) and Ashbaugh and colleagues (1995). McKenna and associates (1991) noted that failure to follow traffic rules and unsafe riding practices on the part of the cyclist, were the primary reason cited as the cause of the bicycling accidents they reviewed. The findings of Ashbaugh and colleagues (1995) paralleled those reported by McKenna et al. (1991). Ashbaugh and colleagues found that among those injured in bicycle-motor vehicle collisions, the bicyclist was overwhelmingly responsible for the accident, 87% versus 13% (Ashbaugh et al. 1995). Failure to follow traffic rules, including running a stop sign or red light, and various midblock violations including riding against traffic, and running into cars pulling out of parking spaces, were among those documented by police (Ashbaugh et al. 1995). Ashbaugh and associates (1995) found no age-specific behavior pattern in relation to cyclist error. Rather, they noted that children aged 5-9 years were nearly equally as likely to violate traffic rules, as children aged 10-14 years.

Unlike studies with a primarily pediatric sample, those studies representative of the population as a whole, or which had an essentially adult population, reported disparate results (Yelon et al. 1995; Tucci and Barone 1988; Watts et al. 1986). An earlier study by Watts and associates (1986) utilized a subject population with an average age of 22 years. Watts and associates noted that 53% of the road cycling accidents in Boulder, Colorado were the fault of the motor vehicle driver. Among those, 90% of the bicycle accidents had occurred due to failure of the motor vehicle operator to see the cyclist. Of those accidents that occurred during dusk to dawn hours, 42.8% of the cyclists had reflectors, 8.9% had lights, while 48.3% had neither (Watts et al. 1986). Poor road conditions such as gravel on the road (34%) and miscellaneous factors including rain drainage grates, potholes, curbs, and other obstructions (37%) were cited as contributing to the bicycle accident (Watts et al. 1986).

Tucci and Barone(1988), reverberated the findings of Watts and associates (1986) in their study. Tucci and Barone interviewed 27% of the injured urban adult cyclists in New York, and found that 70.7% of the adult cyclists injured were not responsible for their accidents. Either inattentiveness or carelessness on the part of the motor vehicle operator was cited, or poor road conditions were found to be responsible (Tucci and Barone (1988). In only 26.8% of the cases, was the cyclist cited to be at fault due to failure to follow traffic rules. Notably, this is contrast to the above studies with a primarily pediatric sample population (Ashbaugh et al. 1995; McKenna et al. 1991; Selbst et al. 1987; Ernster & Gross 1982). However, an important distinction made by Tucci and Barone (1988) was that the cyclists in their sample population were primarily experienced cyclists, cycling an average of 48 miles per week. This may partially explain the reversal of fault noted in this study.

<u>Helmet Usage Patterns</u>

Lack of helmet use among all age groups remains apparent today, despite many attempts to increase their use. None of the bicyclists injured in the majority of studies were reportedly wearing helmets, or safety equipment of any type (Boswell et al. 1996; Zavoski et al. 19195; Yelon et al. 1995; Ashbaugh et al. 1995). Selbst and associates (1987) found that only 3 of 520 (0.6%) of the injured cyclists in their study were wearing helmets at the time of the accident, although 8% reported that they owned a helmet (Selbst et al. 1987). The reasons children cited for not wearing helmets in Ashbaugh and associates (1995) study varied from "never though of it," "not necessary," to "does not ride often," and "could not afford one" in children who did not own a helmet, to "does not know" and "in a hurry and forgot" in children who did own a helmet, but were not wearing one at the time of the accident.

Various studies discovered that older bicyclists were generally more likely to don a cycling helmet, than younger bicyclists (Watts et al. 1986; Tucci and Barone 1988; Spaite et al. 1991; Frank et al. 1995). Watts and associates (1986) registered a 14.6% hard helmet wearing rate, along with one (0.4%) rider who wore a leather helmet. Comparably, Tucci and Barone (1988) reviewed the emergency room records from a primarily adult urban hospital. In their query of a sub-sample of 41 of 153 injured bicyclists, among those interviewed 14.6% (6/41) reportedly wore a bicycle helmet at the time of their accident.

Frank and colleagues (1995) and Spaite and associates (1991, 1995) reported comparative data for adults and children. Frank and colleagues (1995) documented that 9 (7%) of the injured adults, in comparison to only 3 (2%) of the injured children where found to being a helmet at the time of their accident. In their examination of bicyclists injured exclusively in a bicycle-motor vehicle collision, Spaite and associates (1991) discovered that a rather large percentage of their patient population was wearing a helmet at the time of the accident (40.9%). Helmet use was more prevalent among adults over the age of 18 years (50.9%), than among children 18 years or younger (13.5%) ($p < 0.0001$). Notably however, a greater proportion of helmet users had an ISS less than 15 (55.3%). In addition, fewer helmet users had fatal accidents (9.1%). Based on the findings of the above researchers, the greater proportion of helmet users in Spaite and associates (1991) study may be attributed to both increased public awareness of their importance, and an older subject population (mean age 23 years).

Spaite and associates (1995) found similar findings in their later publication. Recall that data for both studies was prospectively examined from those bicyclists who presented to the Emergency Department at the University Medical Center in Tucson, Arizona. The former study included all subjects injured in a bicycle-related accident, while the later study included adults only. Determination of the influence of BAL's on the ISS, helmet use, and medical resource allocation was focus of this later publication (Spaite et al. 1995). A significant difference in helmet use was noted between those cyclists injured with a BAL > 0, versus those with a BAL < 0 and with no clinical evidence of alcohol consumption ($p = 0.0004$). Two of 29 patients (6.9%) with a BAL > 0 were documented as wearing a helmet at the time of their accident, in comparison to 109 of 321 (34%) of patients with no detectable signs or symptoms of helmet use. These results raise questions about the impact of alcohol intoxication on bicycle-related injuries, especially in lieu of the vast amount of community and media publicity surrounding intoxicated automobile and motorcycle drivers. However, due to the limitations of available and the time associated with this manuscript, analyses concerning this topic will be restricted to discussion only.

Using a similar study design as that reported by Tucci and Barone (1988), but utilizing a younger sample population (children less than 16 years of age), Nakayama et al. (1990) conducted a telephone interview of a sample of 82 families from the 372 children admitted to the Children Hospital of Pittsburgh for bicycle-related injuries. Helmet use was one of the topics of inquiry. Nakayama et al. (1990) discovered that of the 82 families interviewed post-accident, only 3 children (3.7%) had been wearing a helmet at the time of the accident, and only 6 children (7.3%) reportedly wore bicycle helmets prior to their accident, a finding that was delineated in a subsequent publication of the same data (Nakayama, Pasieka & Gardner 1990). Additionally, Nakayama et al. (1990) noted that only 20 (24.4%) of the injured children wore helmets following their accidents.

Among those studies which sought to evaluate the incidence and epidemiologic data of bicycle-related head injuries, or isolated bicycle-related head injuries from a review of all causes of head injury, helmet usage rates were documented as lower than those from studies assessing bicycle-related injuries in general (Warren et al. 1995; Jaffe et al. 1993; Belongia et al. 1988). Only 1 (1%) of the sub-sample of head injured cyclists interviewed post-accident by Belongia and associates (1988) was wearing a helmet at the time of the accident. Comparably, only 3% of all patients who sustained traumatic brain injury from a bicycle-related accident were wearing a helmet at the time of their accident in the study conducted by Jaffe and colleagues (1993). Warren and associates (1995) further confirmed the finding of Belongia and associated and Jaffe and colleagues, in their evaluation of the traumatic head injuries in Alaska. Warren and associates found that 90.9% of the bicyclists who sustained a traumatic head injury in Alaska, were not wearing helmets.

The four year study conducted by Li and associates (1995) accessed data from the National Pediatric Trauma Registry (NPTR), a database formed by 62 trauma centers. The study included data from the years 1989 through 1992. Helmet usage patterns similar to those reported by the researchers in the above studies were found. Of the 2333 bicycle-related injuries recorded, 26 (1.1%) reportedly were wearing helmets at the time of injury, versus 1512 (65%) who were not, and 795 (34%) whose helmet usage was unknown at the time of injury. Of the 26 injured cyclists who were wearing a helmet at the time of their accident, 10 sustained some form of head injury (38.5%). In comparison, 63.9% of the non-helmet wearers (890/1512), and 44.3% of the cyclists whose helmet usage was unknown (352/795) reportedly incurred a head injury. Li et al. (1995) further estimated the odds ratio and 95% confidence interval for the bicycle-related head injured pediatric trauma patients using multivariate logistic regression. Li and associates found no significant difference between helmet wearers (reference group) and non-helmet wearers (CI = 0.92 to 4.62), despite an odds ratio of 2.06. However, a significant difference between helmet wearers and the group of cyclists whose helmet status was unknown was found (OR = 1.69, CI = 1.41 to 2.02, $p < 0.01$). Nonetheless, due to the small number of helmet wearers, any definitive protective benefit of the helmet in the prevention of head injury, based on these results, would be premature.

The greatest non-mandated bicycle helmet compliance was reported by Thompson and associates (1990) who noted that 15.4% of all injured cyclists in their study were wearing helmets at the time of their accident. The age-associated helmet use distribution was documented as 4.3% among children under the age of 15 years, 23% for young adults ranging in age from 15-24 years, culminating in 44% among those 25 years of age and older. Gender specific differences in helmet use were not found to be statistically significant (Thompson et al. 1990). Contrary to Thompson et al. (1990) and all other researchers referenced in this section, the subjects of Kronisch and colleagues (1996) were competitive cyclists who were required to wear a bicycle helmet or forfeit competition. This helmet mandate was passed by the U.S. Cycling Federation in 1986. Thus, all 16 injured cyclists participating in the July 1994 competition were wearing a helmet at the time of their injury.

The positive association between helmet use and age noted by the above authors, especially between those less than 16 years, versus those greater than or equal to 16 years, appears paradoxal when viewed in light of the many State mandates. Moreover, according to the above studies, helmet usage documentation is inconsistent among studies focusing on head injuries, and those evaluating bicycle-associated injuries in general. Collectively, helmet usage rates do not appear to be increasing, despite the efforts and strategies promoting their use.

Substance Abuse

With the exception of a few authors, toxicology screens are infrequently reported (Kraus et al. 1987; Selbst et al., 1987; Kraus et al. 1990; Frank et al. 1995; Spaite et al. 1995; Yelon et al. 1995). The role alcohol, and other controlled substances, played in the incidence of bicycle-related injuries appeared to gain interest in the mid 1990's (Frank et al. 1995; Spaite et al. 1995; Yelon et al. 1995). Among those researchers who included toxicology screens in their study design, alcohol was generally the targeted substance.

Although alcohol levels were not measured in the study conducted by Selbst and associates (1987), all participants were questioned as to whether they consumed alcohol prior to their accident. Only 1 of 520 children injured in a bicycle-related accident admitted that alcohol may have played a role in their accident. Subsequent to Selbst and associates (1987), Kraus and colleagues (1987, 1990) reported the blood alcohol levels (BAL's) of all injured bicyclists over the age of 14 years. Similar blood alcohol levels were not reported on those less than 15 years of age, as blood alcohol tests were not routinely performed on this age group. However, among the 98 brain injured bicyclists over the age of 14, twenty-three (23.5%) had blood alcohol tests within 4 hours of their injury. Of those tested, over 65% had a blood alcohol level of $\leq$ 1 mg/dL, while 52% were considered legally intoxicated with a blood alcohol level of $\geq$ 100 mg/dL (Kraus et al. 1987).

Similar to Kraus and colleagues (1987) Spaite and associates (1995) studied the effects of alcohol consumption on those 18 years of age and older, who were admitted to the University Medical Center in Tucson, Arizona, from January 1, 1991 through October 31, 1992. Spaite and associates found that of the 350 subjects included in their study, 29 were noted to have BAL's > 0. Further sub-analyses of their data revealed that helmet use and ISS differed significantly among those with BAL > 0, in comparison to those with a BAL < 0 and absence of clinical symptoms of alcohol use. As previously noted, helmet use for the intoxicated group was low (2/29, 6.9%), while the mean ISS was higher (10.3) than that of the alcohol free group. The comparative statistics for the alcohol free group were 109/321 (34%) for helmet use, and 3.3 for a mean ISS score. The values for the two groups were significantly different at $p = 0.0004$ for helmet use, and $p = 0.0001$ for ISS.

Like Spaite and colleagues (1995), toxicology screens were performed on all patients in Yelon and associates study (1995). Positive blood alcohol concentrations were noted in 14 (16.7%) of all patients, with a 201 (range 138-291 mg/dL) average BAL. Among those positive for alcohol, three (21.4%) were reportedly positive for other drug substances as well (Yelon et al. 1995). Blood ethanol levels were also evaluated by Frank and associates (1995). A total of 107 of the 311 (34.4%) bicyclists were tested. Of the 107 tested for blood alcohol levels, 65 (61%) were adults, representing 53% of all adult bicyclists in the study. The remaining 42 were children, which represented 22% of all child cyclists in the study.

Summary

The studies reviewed in this section reveal that bicycle accidents are more prevalent among males, and children less than 16 years of age. The majority of bicycle crashes result from nonmotor vehicle accidents, although, bicycle-motor vehicle collisions account for the greatest proportion of severe and fatally injured cyclists. The two primary classifications of injuries resulting from bicycle-related accidents are orthopedic and neurologic injuries. Neurologic injuries, namely severe brain injuries, appear to be the leading cause of bicycle-related fatalities. However, the incidence of head injuries resulting from bicycle-related accidents appear to have remained fairly constant over the years, as evidence by the percentages and rates reported by the above researchers. This finding is in lieu of the marked increase in the popularity of bicycling reported by various national and consumer reports.

Helmets have been shown to be effective in the prevention of serious and fatal head injuries. However, their efficacy in the reduction of minor injuries, which comprise the largest percentage of bicycle-related head injuries, does not appear to be as convincing. In their review of cyclists injured as a result of a collision with a motor vehicle, Spaite and associates (1991) noted that 55.3% of the 70.1% of cyclists with an ISS score < 15 were wearing a helmet at the time of the accident. Thus, upon examination of cyclists with less severe injuries, Spaite's and associates (1991) found that the number of cyclists wearing a helmet at the time of their accident, did not appear substantially greater than those cyclists not wearing a helmet at the time of their accident.

Racial and socioeconomic considerations uncovered disparate results. Although traumatic injuries by all mechanisms were noted to be more prevalent among minorities, inconsistent results were reported among race-specific bicycle accidents. In contrast, the socioeconomic structure of the sample population emerged as a potential contributing factor to overall injury rates. Several researchers found a preponderance of bicycle-related injuries in those living in lower income and poverty areas.

Assessment of accident characteristics revealed that the majority of bicycle accidents occurred throughout the summer months, during daylight hours, and on clear days. In general, bicycling accidents appeared more likely among suburban bicyclists than urban bicyclists. Moreover, children involved in bicycle-related accidents were commonly noted to be riding in groups with other children at the time of their accidents.

As one may anticipate, substance abuse among injured bicyclists appears to be positively associated with injury severity and negatively associated with helmet use. However, the problem is not exclusive to adults. Rather, subjects under the legal drinking age have tested positively for the presence of alcohol in their blood. While little research has been conducted in this area, further monitoring of this issue, may prove to be beneficial for injury prevention researchers.

Potential biases and limitations of the above studies centered on methodological issues. The majority of studies were not representative of the population as a whole, as few minorities and lower income families were included. The selection of medical centers servicing middle and upper-middle class communities, rather than indigent communities, likely influences this bias. The examination of only hospitalized primary care patients, or combined primary care and tertiary care patients, as done by most of the above authors, notably alters the actual percentage of certain injuries for a given community. Misleading information regarding the frequency, costs, and severity of patients results (Waller, Skelly, Davis, & Herreid 1991). How and why? The answer to the first question is most explicit. The inclusion of only hospitalized primary care patients and combining primary care patients with tertiary care patients is a practice that most often results in the presentation of data from patients with the most serious, and the most costly injuries. Waller and associates (1991) accent that this practice is most common among surgical departments, due to the nature of their patients. Why does this happen? A more sensitive, although possible deceiving, problem. Reporting data in this form without detailing its limitations and biases is misleading to the audience, whomever it may be. Whether it be physicians reporting to hospital administrators, hospital administrators reporting to the hospital board or to some regulatory group, the outcome will be the emphasis on the more serious injuries to certain body regions. Therefore, use of the information to establish or verify the need of some community programs, without delineating its limitations will mislead the target audience. A more detailed discussion of this issue will be presented in the final section of this chapter.

Non-Hospital Based Studies

Regional Injury Profiles

Non-hospital based studies, those that either focused on cyclists or segregated cyclists in their injury profile, were distinguished from hospital based studies to examine whether similar injuries would be noted in the different sample populations. The majority of studies included in this section collected data from governmental sources (namely death certificates), medical examiners' reports and autopsy data, police reports, or some combination of the above. The next two sections will examine observational, questionnaire, and survey data separately, followed by program efficacy studies. Lastly, a comprehensive summary synthesizing the various regional and national studies, will be furnished at the end of this chapter.

Population Specifications with Injury and Mortality Data

The examination of bicyclist fatalities were reviewed by several researchers through the use of death certificates, and medical examiners and autopsy records (Fife et al. 1983; Division of Epidemiology 1990; Cowan et al. 1993; & Hawley et al. 1995). Fife and associates' 1983 Florida study is one of the most frequently cited manuscripts in this body of literature. Fife and associates (1983) analyzed autopsy data from all fatally injured bicyclists in Dade County, Florida between March 1956 and December 1979. Among those injured, 50% were noted to have serious head and neck injuries as demonstrated by an Abbreviated Injury Severity Score (AIS) of ≥ 3 (1976 version of AIS). Moreover, 86% of the fatally injured cyclists presented with head and neck injury as their most serious injury (AIS of 4-6). Most notably however, was that Fife and associates (1983) documented that of all the fatally injured bicyclists, 92% of the 110 cases with skull fractures and 62% of the remaining 63 cases had sustained brain injury. Thus, the reported relative risk of brain injury when contrasted with those cyclists with and without skull fracture was 6.9 ($p < 0.001$).

Distinct from Fife and associates' study however, Cowan and colleagues (1993) not only examined autopsy reports, but also included death certificate data. Furthermore, their study was not solely inclusive of bicycle injuries. Rather, Cowan and colleagues examined all head and spinal cord fatalities in the state of Delaware during 1990 in an attempt to ascertain the cause of these often debilitating injuries. Cowan and colleagues documented 122 fatal head injuries for Delaware residents; eight of which were both head and spinal cord injuries. This corresponds to 37% or 18.3 fatal head injury deaths per 100,000 residents (Cowan et al. 1993). The age-group spanning the years 15-34 accounted for the greatest percentage of fatalities resulting from head injuries; 23.8% or 28.8 per 100,000 for those aged 15-24 and 24.6% or 25.8 per 100,000 for those aged 25-34. However, despite these striking numbers, Cowan and colleagues found that only 2 (1.6%) of all fatal head and spinal cord injuries in Delaware during 1990 were sustained by a bicyclist. Both bicyclists suffered fatal head injuries. This finding adds crecidence to the position that although bicycle-motor vehicle collisions comprise only a small percentage of all bicycle accidents, the severity of the injuries resulting from such collisions generally produces the most debilitating injuries.

Analogous to Fife and associates (1985) and Cowan and colleagues, Hawley et al. (1995) reviewed the autopsy reports of all cases involving bicyclists in Indiana from 1984-1993. Hawley and associates (1995) reported that bicycle-related fatalities accounted for only 0.55% (36 of 6552) of all autopsy cases examined by the Forensic Pathology section at the Indiana University School of Medicine in Indianapolis. However, among bicyclist fatalities, it was noted that 96% of the bicyclists sustained a fatal head injury as a result of a collision with a motor vehicle. Because Fife and associates (1985) did not provide the total of number of autopsies performed during their period of study, a more direct comparison cannot be made between the incidence of fatal bicycle-associated injuries that presented for autopsy in both Florida and Indiana, respectively. Nonetheless, the greater percentage of bicycle fatalities reported by Fife and associates (1985) for Dade County, Florida may potentially be a reflection of the higher than average number of bicycle-related fatalities in Florida, as reported by the U.S. Department of Transportation 1980 through 1994, despite the fact that those include only bicycle-motor vehicle collisions (See Figure 3). Regardless of the reason for the discrepancy between the two studies, the large percentage of fatal head injuries sustained by bicyclists in both, is characteristic of the pattern noted in the hospital-based studies.

Unlike the above studies, Halek and associates (1980) assessed the number of pedalcycle accidents in Tucson, Arizona during 1977, through the examination of police records only. Distinct from the proceeding studies, however, was that 3% of the cases were non-motor vehicle related accidents. One Hundred and Seventy-four bicycle-related traffic accident reports were identified. Among those, 169 (97%) were motor-vehicle related. Males exceeded females in both the number and severity of injuries in all age groups. Although the exact age-sex specific numbers or proportions were not provided, a graphical display of the data revealed that males aged 16-25 years experienced the greatest number of injuries, most of which were classified as non-incapacitating injuries. Among females, the same age group (16-25 years) was reported to be at highest risk. However, Halek and colleagues (1980) remarked that while the location and age distribution of bicycle-related traffic accidents appeared evenly distributed in most parts of the city, a higher percentage of accidents for those aged 16-25 years was recorded in the area surrounding the University.

A cluster of studies confined their sample to the examination of bicycle-motor vehicle collisions only (Williams 1979; Gerberich, Parker & Dudzik 1994; Lambert 1995). The primary sources of data for these studies were police reports, and the National Highway Traffic Safety Division and Department of Public Safety records, in a given state. Williams (1979) aimed to evaluate age-associated factors that may contribute to bicycle-motor vehicle collisions. The police records of bicycle-motor vehicle collisions occurring in Maryland from October 1, 1971 to September 30, 1972, were obtained from both the City of Baltimore and the Maryland State Police Departments. Graphic and narrative descriptions of the accidents were obtained from police reports, and were used to determine responsibility for the accidents. Vehicle movement criteria were reportedly used to identify whether the bicyclist or the driver initiated the collision. Consequently, this decision was based solely on the report from the officer at the scene. A total of 888 of the 895 (99%) bicycle-automobile collisions were reviewed. Among these, 1% were fatal, 39% had Type A injuries (defined as a "bleeding wound, distorted member, an injury that required the bicyclist to be carried from the scene"), 41% had Type B injuries (defined as lacerations, "bruises, abrasions, swelling, limping"), and 17% sustained Type C injuries ("no visible injuries but momentary unconsciousness or complaint of pain") (p. 370).

Over a decade later, Gerberich and colleagues (1994) focused their attention on assessing the type, severity and outcome of bicycle-automobile accidents in Minnesota during 1984. One thousand two hundred and eighty-two bicycle-motor vehicle accidents occurred in Minnesota during 1984. Of those, 1258 (98%) were non-fatal. A total of 925 cases involving victims aged 12 years or older were identified by the Department of Public Safety records (Gerberich et al. 1994). Questionnaires were mailed to all 925 victims within 24 months of their reported accident. The questionnaire sought to gather injury outcome information from all victims, and was accompanied by a cover letter detailing the study's purpose, an informed consent form, and a self-addressed and stamped envelop. Of the 925 questionnaires mailed, 498 were completed and returned, and 151 were returned as undeliverable, for an overall response rate of 64.3%. As is characteristic of the majority of bicycle injury victims, 66% of all respondents were male. The mean age of the respondents was 21.1 years.

Comparable to earlier findings, Gerberich and associates (1994) found orthopedic injuries to be the prevailing injury sustained by the sample of bicyclists they surveyed

(Yelon et al. 1995; Selbst et al. 1995; Tucci and Barone 1985; Friede et al. 1985; & Ernster & Gross 1982). Interestingly however, when Gerberich and colleagues (1994) examined injuries according gender, a sex-specific pattern was noted. Upper extremity injuries (arm/hand) were found to predominate in males (22%), while lower extremity injuries (knees) were noted to predominate in females (12%). Ironically, the two body locations (upper and lower extremity) remained the primary cite for the next three most common types of injury, but reversed in order of location. Specifically, proceeding injury locations in males were leg/foot/ankle (20%), knee (16%), and head (14.5%). Conversely, the succeeding injury locations for females were arm/hand (11%), leg/foot/ankle (11%), and head (9.5%). This sex-specific injury location profile was not noted by previous researchers, as they did not distinguish between males and females in their report of injury location (Yelon et al. 1995; Selbst et al. 1987; Friede et al. 1985; Ernster and Gross 1982). However, because males typically sustain an overwhelming majority of bicycle-related injuries, it may explain why lower extremity orthopedic injuries were most common in many studies. Further examination of sex-specific injury patterns, may provide insight into sex-appropriate safety gear and bicycle design.

In their assessment of the victims of who sustained multiple injuries, Gerberich and colleagues (1994) once again found orthopedic injuries to be the most frequent anatomical injury cite, in both males and females. The three leading anatomical injury cites for multiple injuries, were lead by arm/hand injuries comprising 13% of male and 9% of female injuries. Approximately equivalent reports of knee injuries (11% for male and 6%

for females) and head injuries (11% for males and 7% for females) followed, respectively. Similarly, the three most common types of injuries at a single site were also identical for males and females. Bruises overwhelming lead the list, followed by lacerations and concussions (defined as loss of consciousness and/or loss of awareness/amnesia) (Gerberich et al. 1994). Additionally comparable results for males and females, were the three most prevalent injuries sustained at multiple anatomical sites: bruises, lacerations and sprains/strains. Seventy six percent of all injured cyclists reported seeking medical attention for their injuries. Recovery post-accident varied from less than two days (16%), to two or more days without hospitalization (15%), to hospitalization (14%). Among hospitalized patients, the length of stay varied from less than two days (5%) to two to six days (2%) to one week or more (7%). Seven percent of injured bicyclists necessitated surgery (Gerberich et al. 1994). Unique to Gerberich and colleagues' (1994) study was the evaluation of initial injuries sustained two years following their bicycle-automobile collision. Gerberich and associates (1994) reported that 21% of all respondents indicated that they had not fully recovered from their injuries, while 7% were unsure. Among those reporting residual problems, 26% stated that they had chronic pain or other unresolved problems that adversely affected their normal activities (Gerberich et al. 1994). Residual pain was the principal complaint (48%), followed by scarring (9%) and paresthesias (5%). More severe residual conditions included paralysis (1%), hearing disturbances (1%), visual disturbances (1%), and memory loss (2%) (Gerberich et al. 1994).

Lambert (1995) similarly chose to examine bicycle-automobile accidents.

However, the focus of Lambert's (1995) paper was to increase the physician's awareness regarding the risks of cycling, and the scope of bicycle-automobile accidents. Lambert held the perception that physicians often recommend cycling as form of exercise to increase cardiovascular fitness, without expressing the potential dangers of the activity. Lambert (1995) acquired the needed data from the Traffic Safety Division of the Arkansas State Highway and Transportation Department. This division collects information from police records from all local, state and municipal law personnel (Lambert 1995). All bicycle-motor vehicle accidents from 1991 through 1993 were included in Lambert's review.

Although the definitions used to define head and/or brain injury in each of the above studies may have differed slightly, the record of reported injuries cannot be over-looked. A more detailed examination of factors that may have contributed to the bicycle related injuries and fatalities presented in this section, are discussed below.

Age and Gender Patterns

Characteristic age and gender patterns include younger cyclists, primarily adolescents, and males. All studies in this section supported this pattern. Data provided by Fife and associates (1983) revealed that 80% of the documented cyclist fatalities were sustained by males. Males reportedly exceeded female deaths in all age groups, with the greatest disparity noted in older riders (50+ years). The age range for patients in Fife and associates' study (1985) was 3 - 92 years, with a median age of 14 years. Among those cyclists fatally injured as a result of bicycle-motor vehicle collisions in the study conducted by Hawley and colleagues (1995), 27% were males under the age of 16 years, 54% were males over the age of 16 years, and 27% were females under the age of 16 years. Age-sex data was not provided for non-motor vehicle accidents (Hawley et al. 1995).

Similar results were found by the New York State Department of Health, Epidemiology Division (1990). The New York Department of Health noted that 5-14 year old children comprised one third of all cyclist deaths in New York between 1984-1988, followed by cyclists between the ages of 15-24 years (30%). Of the approximated 10,000 per year injuries sustained by bicyclists involved in bicycle-motor vehicle collisions in New York, 38% were between the ages of 15 and 24 years, and 33% were between the ages of 5 and 14 years (Division of Epidemiology 1990). Age-sex data was not provided by Cowan and colleagues (1993). Their omission of the data was probably due to the small number of bicycle-motor vehicle collisions reported in their study (n=2).

Among those studies which restricted their sample to bicycle-automobile collisions, Williams (1979) noted that 886 of the 888 injured cyclists in Maryland from October 1971 to September 1972, had documented ages. The largest proportion of children injured were between the ages of 10 and 14 years (43%). No children less than 4 years old were injured, and 280 (32%) children aged 4-9 years were injured. Teenagers and adults comprised the fewest percentage of injured cyclists with 151 (17%) and 76 (9%) of those aged 15-19 years and 20 years or over, respectively (Williams et al. 1979). Furthermore, the majority of injured cyclists in Williams and associates study, were noted to be male (84%).

Gerberich and associates (1994) reported comparable findings. They reported that 48% of all respondents who previously sustained a bicycle injury as a result of a bicycle-motor vehicle collision, were less than 17 years of age. Of those, 13 and 14 year old children accounted for a large number of all cases with 12% and 14%, respectively (Gerberich et al. 1994). Overall, children and young adults aged 25 or less, comprised the majority of bicycle-automobile collision victims (79%). Gerberich and associates (1994) noted an inverse relationship between age and the incidence of bicycle-motor vehicle collision. Children aged 12-14 years were found to have the highest injury rate at 164 per 100,000, with teenagers aged 15-19 years possessing a rate of 71 per 100.000. As expected, males reportedly maintained higher rates than females in all age groups (Gerberich et al. 1994).

Consistent with the above results, Lambert (1995) noted that children less than 15 years of age comprised the majority of bicyclists injured in collisions with motor vehicles. In his review of the bicycle-motor vehicle collisions in Arkansas from 1991-1993, Lambert noted that children aged 14 years or younger comprised greater than 50% of all bicycle fatalities resulting from collisions with motor vehicles, with yearly proportions of 57% (4/7), 75% (3/4), and 50% (3/6), respectively. Similarly, this same age-group of children sustained the majority of injuries from bicycle-motor vehicle collisions as well. However, because the numbers provided do not add to the total number of fatalities and injury victims, exact proportions are difficult to calculate.

Race and Socioeconomic Considerations

Race or socioeconomic considerations were not addressed by the majority of investigators, nor were they included in the brief report from the Division of Epidemiology, New York (1990) (Williams et al. 1979; Fife et al. 1985; Gerberich et al. 1994; Hawley et al. 1995; Lambert et al. 1995). Although, Cowan and associates (1993) did provide information that differentiated the observed death rate by race, further separation of the data by external cause, thereby separating bicyclists from all other causes, was not done. In lieu of the disparate injury and mortality results when race and socioeconomic issues were considered by investigators utilizing hospital based data, the inclusion of this information in governmental databases may be warranted.

Time of Day/Week and Seasonal Variations

Neither Hawley and colleagues (1995) nor Cowan and colleagues (1993) provided seasonal or time of day or week data. Either the data was not available or the data pertaining to bicyclist fatalities was not distinguished from all other causes of death. Conversely, Fife and associates (1983) did describe the occurrence of bicycle accidents. They noted that neither the day of the week nor the month resulted in a statistically significant relationship with the number of bicyclists fatally injured. However, a noticeable pattern was found among bicyclists fatally injured according to the time of day of their accident. Fatal bicycle accidents appeared reportedly most prevalent during the mid afternoon and early evening hours from 3-9 PM (Fife et al. 1985). Comparable data was not provided in the summary report presented by the Division of Epidemiology, New York (1990).

The prevalence of bicycle accidents during daylight hours was documented by a number of researchers (Williams 1979; Halek 1980; Gerberich et al. 1994; Lambert 1995).

Similar to Fife and associates (1983), Williams (1979) noted that 86% of the bicycle-automobile collision in Maryland during 1971-1972, occurred during daylight hours, with the hours 3:00 PM to 9:00 PM accounting for 65% of all accidents. An age-specific time pattern of the incidence of bicycle-motor vehicle collisions was also discovered. Children between the ages of 4-9 years, and 10-14 years reportedly sustained the largest percentage of injuries between 4:00 PM and 5:59 PM, when compared to children aged 15 years and older. Surprisingly, Williams and associates (1979) also found children aged 4-9 years to be most likely to incur and injury between the hours of 6:00 PM and 6:59 PM. In contrast to both Williams (1979) and Fife and associates (1983), Halek and colleagues (1980) reported the peak hours of pedalcycle accidents in Tucson, Arizona, to be between 8:00 AM and 4:30 PM.

The prevalence of mid-afternoon and early evening hours noted by Williams (1979) and Fife and associates (1983), was supported several years later by Lambert (1995). Lambert (1995) discovered that the mid-afternoon and early evening hours from 3-7 PM, accounted for 50% of all bicycle-automobile accidents in Arkansas during 1991-1993. Comparably, Gerberich and associates (1994) found that the incidence of bicycle-automobile accidents reported to the Department of Public Safety in Minnesota during 1984, peaked between the hours of 3-6 PM, accounting for 34% of all accidents. The remainder of bicycle-automobile collisions in Minnesota that occurred during daylight hours, reportedly happened between the hours of 12-3 PM and 6-9 PM, each comprising 20% of all accidents.

Day of week and seasonal variations in the incidence of bicycle-motor vehicle collisions were documented by Williams (1979), Halek and colleagues (1980), and Gerberich and associates (1994). Summer prevailed as the most common period for bicycle-related accidents (Williams 1979; Gerberich et al. 1994). Williams (1979) noted that 72% of the bicycle-automobile collisions they reviewed happened between May and September. Similarly, Gerberich and colleagues (1994) reported that bicycle-automobile collisions were most common during June, July, and August, accounting for 19%, 24%, and 18% of all collisions, respectively.

Unlike the seasonal pattern noted above, bicycle-automobile accidents did not appear to favor any one day of the week. All researchers reporting day of week accident patterns, found different results. Williams (1979) noted that bicycle-automobile accidents were most likely to occur on Monday's (17%), Friday's (16%) and Saturday's (16%) in Maryland. In contrast, Gerberich and associates (1994) found the largest percentage of bicycle-automobile collisions in Minnesota occurred mid-week, namely Tuesday (18%) and Wednesday (19%). Similar to both Williams (1979) and Gerberich and associates (1994), Halek and colleagues (1980) reported that weekday accidents were more prevalent than weekend accidents in Arizona. Saturday and Sunday were the least likely days for bicycle-automobile collisions in both Arizona and Minnesota (Halek et al. 1980; Gerberich et al. 1994). Halek and colleagues (1980) postulated that the prevalence of weekday pedalcycle accidents may possibly be more related to the density of motor vehicle traffic, than to an increase in recreational cycling volume, as would be expected on the weekend.

Weather Conditions

Of the studies reviewed in this section, three considered the role of adverse weather conditions in the occurrence of the bicycle accidents (Fife et al. 1983; Gerberich et al. 1995; Lambert 1995). Fife and associates (1983) evaluated bicycle-related fatalities by weather conditions at the time of the accident. Although the presence of rain was the only adverse weather condition assessed, no statistically significant relationship was noted between bicycle fatalities and rain condition. Roads described as "wet" or "slick" at the time of the accident, reportedly accounted for 4% and 8% of all bicycle-automobile accidents in the studies conducted by Gerberich and associates (1995) and Lambert (1995), respectively. More detailed weather specific information was not provided by either one of these authors.

Location and Collision Type

The largest number and proportion of bicycle fatalities incurred from bicycle-motor vehicle collisions was documented by Fife and associates (1983). They noted that 100% of 173 bicycle-motor vehicle collisions resulted in death in Dade County, Florida, from 1956-1979. The types of automobiles involved the fatal collisions with bicycles included, passenger automobiles (81%), trucks (13%), motorcycles (3%), busses (2%) and motor vehicles of unknown type (2%). Percentages are one percentage over due to rounding.

The preponderance of bicycle-automobile collisions as the leading cause of mortality among cyclists was substantiated by the remaining authors in this section. New York State Department of Health, Epidemiology Division (1990) reported that more than 77% of bicycle fatalities resulted from collisions with motor vehicles, compared to 21%

from non-motor vehicle accidents. Although Cowan and colleagues' (1993) review of death certificate data for head injured patients in the state of Delaware during 1990, revealed only 2 bicycle-related head injury mortalities, both resulted from collisions with motor vehicles. Comparably, 72% of the bicycle fatalities evaluated by Hawley and colleagues (1995) were found to be the result of bicycle-motor vehicle collisions, while 3% (n=1) involved a pedestrian walking a bike, 8% (n=3) resulted from fatal falls from a bike, 6% (n=2) were the fallout of intentional cyclist murders by gunshot, 8% (n=3) were recorded as deaths by natural disease while riding, and 3% (n=1) as a moped fatal accident involving a motor vehicle. Additionally, one of the bicycle-motor vehicle collisions was also classified as a homicide, as it was allegedly the result of an intentional murder (Hawley et al. 1995).

The remainder of the studies in this section focused exclusively on bicycle-automobile collisions, thereby prohibiting comparisons with non-motor vehicle accidents. However, they did provide information regarding the location of the collisions. The earliest of these studies was conducted by Williams (1979). Williams noted an age-specific distribution among collision locations. An inverse relationship was noted between age and collision location. Williams (1979) found that children aged 4-9 years most frequently were involved in collisions with a motor vehicle while bicycling in a residential area (83%), followed by a shopping or business area (8%). Similarly, 71% of the accidents among 10-14 year old children occurred in residential areas, versus 20% in shopping or business areas. The disparity between these two locations narrowed further among those aged 15 years and older, with 56% of the collisions occurring in residential areas, and 33% in shopping or business areas. This inverse relationship between collision location (residential areas and shopping or business areas) and age, may partially be explained by the increased freedom and work activities of teenagers and adults. More specific roadway information will be reviewed in the next section, as Williams (1979) reported collision type according to age and fault-specific patterns.

Gerberich and associates (1994) and Lambert (1995) chose to report different categories in their examination of bicycle-automobile collisions. Gerberich and associates (1994) reported that the majority of bicycle-automobile collisions they reviewed, occurred on municipal streets (44%) and county highways (29%). Even more specifically, Gerberich and associates found that most accidents occurred at intersections (59%), with 17% of those intersections having no traffic control device (Gerberich et al. 1994). Lambert (1995) provided data analogous to that reported by Gerberich and associates (1994). In the review of bicycle-automobile collisions in Arkansas from 1991-1993, Lambert noted that intersections, primarily four-way intersections, were associated with 60% of all bicycle-automobile collisions (Lambert 1995). Other notable locations included alleys or driveways (17%) and non-junctions (28%).

Assignment of Fault

The issue of responsibility for bicycle accidents was addressed only by those studies restricted to bicycle-automobile collisions (Williams 1979; Halek 1980; Gerberich et al. 1994; Lambert 1995). Cyclists, most often children less than 15 years of age, were found by the majority of researchers of hospital based studies, to be responsible for their accidents. Analogous results were reported by investigators utilizing non-hospital based data (Williams 1979; Halek 1980; Gerberich et al. 1994; Lambert 1995). Williams (1979) found that 78% of all the bicycle-automobile collisions in Maryland, from October 1971 through September 1972, were attributed exclusively to the cyclist, versus 19% which were attributed exclusively to the motorist. Of the remaining 3% of all accidents, responsibility was unclear in 2%, and equally probable in 1%. Analysis of responsibility according to the movement patterns of both the bicyclist and the motorist, revealed that "probable responsibility" was attributed to the bicyclist under the following conditions: 1.) emerging from a minor or side road, onto a major road and intersecting with another vehicle (27%), and 2.) failing to comply with either a stop sign or a yield sign (22%). In contrast, motorists were more likely to be "probably responsible" when making a left turn and colliding with a bicyclist (28%), or when hitting a bicyclist from the rear (28%). The majority of collisions citing younger children at fault, reportedly happened as children entered a major road from a minor road. In comparison, older children and adults were more likely to be found responsible when riding the wrong way on a one-way road, or when colliding with a motorist traveling in the same direction on the roadway (Williams 1979).

Williams (1979) was the first of the researchers reviewed in this section to reveal an inverse relationship between age and "probable responsibility" for daylight collisions. Specifically, children between the ages of 4 and 9 years were probably responsible for 94%

of their daytime accidents, in comparison to 87% of 10-14 year old children and 63% of cyclists aged 15 years and older. Overall, 84% of the 86% total accidents occurring during daylight hours, were attributed to the bicyclist. Interestingly, an equal proportion of male (81%)and female (80%) bicyclists were assigned probable responsibility for their accident. Thus, no significant difference was found between gender and the assignment of fault in Williams' study.

The prototype assignment of fault patterns uncovered by Williams (1979) in his review of bicycle-motor vehicle collisions in Maryland during 1971-1972, was supported shortly thereafter by Halek and colleagues (1980). In their examination of pedalcycle accidents in Arizona during 1977, Halek and colleagues (1980) discovered that children less than 16 years of age were found to be responsible for their collisions with motor vehicles 84% of the time. In contrast, cyclists error was documented 47% of the time among those aged 16-25 years, and only 46% of the time among those aged 25 years and older. Additionally, like Williams (1979) Halek and associates (1980) discovered that of all bicycle-motor vehicle collisions reviewed in their study, over 90%occurred at intersections -- street intersections, or intersections with streets with alleys or driveways.

Unlike Williams (1979) and Halek and colleagues (1980), Gerberich and associates (1994) chose not to evaluate bicycle-automobile collisions according daylight hours or to assign explicit fault. Rather, they focused on roadway and traffic characteristics at the time the bicycle-automobile collisions occurred. Gerberich and associates (1994) learned that roadway surface conditions and features were cited as contributing factors in 21% of all bicycle-motor vehicles collisions in Minnesota during 1984. Among the most commonly cited precipitating factors were sand or gravel (7%), wet surface (4%), steepness (6%), road curve (6%) and an uneven surface (4%).

The assessment of bicycle-related accidents according to traffic characteristics reported by Gerberich and associates (1994) differed from that reported by Williams (1979). Williams (1979) found that 28% of bicyclists were struck by motor vehicle as the motorist was making a left turn, and an equal proportion (28%) were struck by the motorist from behind. In contrast, Gerberich and associates (1994) found that 42% of bicyclists were struck from behind, while only 14% were struck while the motorist was making a left turn.

The examination of bicycle-motor vehicle collisions according to responsibility was not addressed in detail in the study performed by Lambert (1995). Lambert's discussion was limited to the notation that 9% of all accidents recorded in Arkansas from 1991-1993, documented that the vision of the motor vehicle driver was impaired by the sun, glare, rain or trees.

Helmet Usage Patterns

Surprisingly, the majority of studies in this section did not report, or were unable to confirm, helmet use among cyclists (New York Division of Epidemiology 1990; Cowan et al. 1993; Hawley et al. 1995; Lambert 11995). Lack of head protection was most prevalent in the study conducted by Fife and associates (1983). However, this was expected as the data used for their study came from autopsy cases performed between

March 1956 and December 1979, before bicycle helmets were readily available. Thus, it was not surprising that none of the 173 bicycle fatalities documented in Florida during this time period were wearing a helmet.

Another study utilizing data prior to the preventative acceptance of bicycle helmets, was that of Gerberich and associates (1994). In comparison to Fife and colleagues, Gerberich and associates found that 4.2% of the cyclists reportedly involved in collisions with motor vehicles in Minnesota during 1984, were wearing a helmet at the time of the accident. No significant difference was noted between helmeted and non-helmeted cyclists sustaining brain concussions (Gerberich et al. 1994). However, caution should be used in any inferences made from these two studies, since neither educational and safety prevention programs nor safety helmets, were prominent during the periods of investigation. Moreover, Florida consistently possessed statewide traffic crash fatalities percentages sustained by pedalcyclists which were above the corresponding national percentages sustained by pedalcyclists, from 1980-1994. Thus, although comparable data could not be obtained from the U.S. Department of Transportation prior to 1980, a fair assumption may be that similar above average percentages existed in Florida during the time of Fife and associates' study.

Substance Abuse

The potential for substance abuse as a compounding factor was not evaluated by the majority of researchers, or included in the report published by the Division of Epidemiology, New York (1990) (Williams 1979; Cowan et al. 1993; Gerberich et al.

1994). However, it was addressed by a select group of researchers whose studies spanned the last 40 years. Fife and associates (1983) evaluated whether the presence of alcohol may have contributed to the number of bicycle fatalities in Dade County, Florida from 1956 through 1979. Substance impairment was noted in 5% of those fatally injured, all of whom were adults. Similarly, all autopsy cases reviewed by Hawley and colleagues (1995) in Indiana from 1984-1993, were reportedly tested for the presence of alcohol or drugs. No positive cases were recorded. More recently, Lambert (1995) noted that alcohol was involved in 4% of all bicycle-automobile collisions in Arkansas from 1991 to 1993. Further clarification as to which of the operators, bicyclists or motorists, were under the influence of alcohol was not provided by Lambert (1995).

Summary

Similar to the hospital based studies reviewed earlier, the non-hospital based studies comprising this section revealed that bicycle accidents were most prevalent among males, and children less than 16 years of age. Bicycle-motor vehicle collisions notably resulted in more serious, and fatal injuries, with brain injuries most common among fatally injured cyclists. However, orthopedic injuries were noted to prevail among non-fatally injured cyclists (Gerberich et al., 1994).

These researchers did not provide considerable evidence in support of the notion that helmets substantially reduce the incidence of bicycle-related head injuries. Gerberich and associates (1994), found no statistically significant relationship between brain injured cyclists who were wearing a helmet at the time of their accident, when compared to those who were not. This contrasts the findings reported by investigators of hospital-based research studies. Recall, the data reported by researchers of hospital based studies had shown that while helmets were effective in the prevention of serious and fatal head injuries, their efficacy in the reduction of minor injuries, those constituting the largest percentage of bicycle-related head injuries, was questionable.

Examination of the role of accident characteristics in the occurrence of bicycle-related accidents, revealed that a preponderance of bicycle accidents occurred in residential areas, and involved cyclist error. Both of these patterns were found to be inversely related to age; i.e., largest percentage among young children (< 16 years), and lowest occurrence among those 16 years and older. Furthermore, the majority of bicycling injuries were noted to happen most commonly throughout the summer months, during daylight hours, on weekdays, and on clear days.

Racial and socioeconomic considerations were not reported by this group of researchers, which may be viewed as a weakness of these studies. In addition, inclusion of primarily autopsy and death certificate data precludes generalization of these findings to the population at large, as cyclists sustaining non-fatal injuries would thereby be excluded. Nonetheless, separate review of this type of data complements the earlier section which focused more fully on non-fatally injured cyclists. Thus, governmental and legal data may provide the necessary counterbalance to investigators utilizing hospital data, in a manner that has been shown to be susceptible to over-estimation of the severity of bicycle-related injuries, thereby contributing to potentially misleading information.

Observational/Survey Studies

Study designs utilizing observational and survey methodology had three essential aims: 1.) to identify the number and type of injuries sustained by bicyclists with varying levels of experience, 2.) to determine the number of bicyclists, of all ages, using helmets, or 3.) to assess the effectiveness of community, educational, legislative and multi-component programs. The distinct methodology of observational and survey studies warrants that they be reviewed separately from hospital and non-hospital injury studies. The inherent limitations of such designs, namely coverage errors (non-observation and faulty observation errors), the perception of attrition among respondents, cognizance of respondents versus non-respondents on the topic in question, and sample and recall biases are some of the potential limitations encountered by researchers utilizing this methodology (Barnett 1991).

National Observational/Survey Studies

A national telephone survey was conducted by Eichelberger and colleagues (1990) with the aim of assessing parental attitudes and understanding of childhood safety issues. Random digit dialing methods were used to ascertain the sample population of parents with at least one child aged 14 years or less. Five hundred and four parents were interviewed with a subsequent follow-up phone interview of 43 patients to verify accurate recording of the requested information.

Because the aim of Eichelberger and colleagues' study was to evaluate all mechanisms of pediatric injury, limited information was available on bicycle safety.

However, tabulation of parental perceptions of the leading causes of pediatric accidental death, revealed that only 8% of the sample population perceived that bicycle accidents constituted one of the top two causes of pediatric accidental death. One of the most important revelations discovered by Eichelberger and colleagues (1990), however, was that parents of children at greatest risk for sustaining injuries were also those most interested in obtaining additional educational material. Blacks expressed the greatest interest in additional child safety literature and instruction (53%), as did lower socioeconomic families (52%), parents under the age of 30 years (47%), parents with more than 2 children (47%), and parents with children less than 7 years of age (40%) (Eichelberger et al. 1990). These proportions, together with the finding that only 12% of parents stated that they had discussed bicycle and pedestrian safety with their children, underscores the important of educating parents, especially those of children at greatest risk of sustaining bicycle-related injuries (Eichelberger et al. 1990). Furthermore, it accentuates the need for the implementation of injury prevention programs in lower socioeconomic areas with curriculums and strategies that are understandable and financially feasible to the target community.

Discerningly, Eichelberger and colleagues (1990) queried their participants as to whom they perceived to be most influential in their acquisition of child safety information. Parents indicated a preference for information presented to them by their physicians (32%), but stated they felt their children were most receptive to information presented to them by their teachers (30%). Awareness of this predilection may prove beneficial in the development of successful educational safety strategies.

Like Eichelberger and colleagues (1990), Rodgers, a member of the U.S. Consumer Product Safety Commission, published two manuscripts, each of which sought to unveil distinct characteristics and helmet usage patterns perceived by bicycle riders (Rodgers 1994; Rodgers 1995). Both studies utilized data gathered from a June-July 1991 national survey. Descriptive summary data was identical in both publications, indicating that data unique to each publication was referencing the same population. A survey firm in Boston, Massachusetts (Abt) designed and conducted the telephone survey using the Mitofsky-Waksberg random digit dialing method (Rodgers 1994; Rodgers 1995). The composition of the survey was a cooperative effort between the United States Consumer Product Safety Commission (USCPSC), Abt survey firm, and various interested bicycle organizations. The survey took place during June and July 1991, and sought to gain information from only one member of each household contacted. The member with the most recent birthday was uniformly selected. If the selected individual was under the age of 16, the child's parent or guardian was requested to complete the interview (Rodgers 1994; Rodgers 1995). A total of 6,976 residential households were contacted. Among those, 4,346 successfully completed the screening process; thereby yielding a minimum response rate of 71.5%. Of the 4,346, one thousand two hundred and fifty-four interviews with bicyclists or their parents were completed. The remaining 3,092 participants either did not own, or did not use their bicycles in the preceding 12 months. Weights were used to adjust the data, so that population projections could be estimated. Recognized limitations of the survey included the exclusion of approximately 6% of the U.S. population who do not own telephones, and 0.6% of the total U.S. population through the exclusion of the residents of Alaska and Hawaii.

Results of Rogers' (1994, 1995) study indicated that approximately 66.9 million individuals, from an estimated 27.1 million households, rode bicycles in 1991. This corresponded to active bicyclists in approximately 29% of all U.S. households. Bicyclists' ranged in age from 2-77 years, with children aged 10 or less comprising the largest percentage of all riders at 25.2%. The next two largest bicyclist age categories included children aged 11-20 (24.7%) followed by adults aged 31-40 (18.3%). Males comprised 52.3% of all bicyclists, versus 47% females (0.7% were reported as unknown gender).

The socioeconomic status and location of the rider households also differed. The more suburban the household, the higher the educational levels and income in comparison to the U.S. norm, the greater likelihood that it was a rider household. More specifically, approximately 57% of the rider households were located in "small cities or towns, or open farm or country" compared to 32% living in "non-Metropolitan Statistical Areas" (p. 86). Reportedly, only 21% of the rider households were from "a large city or suburb" (p. 86).

Both educational level and income appeared to be positively associated with rider households. Rider households with at least one college graduate approached 50%, in comparison to the U.S. norm of approximately 23% households (Rodgers 1994). Additionally, the median U.S. household income in 1990 was approximately $30,000, while that of rider households was approximately $40,000. Lastly, rider households appeared to be larger than that of the typical U.S. household. Rodgers (1994) reported that "two-thirds of all rider households had four or more members, compared to only about 26% of all U.S. households" (p. 86).

The aim of the first manuscript was to gather information on the "characteristics and use patterns" of the typical U.S. bicyclist (Rodgers 1994). Bicycle characteristics and usage practices, and rider and helmet use patterns, were topics reported by Rodgers (1994). Annual riding time varied substantially from < 25 hours/year (20.2%) to ≥ 600 hours/year (8.1%), with a mean riding time of 236 hours/year, and a median riding time of 105 hours/year. The average riding time for males (246 hours/year) exceeded that of females (224 hours/year). Children aged 10 years or less registered the highest mean annual riding time with 318 hours/year, followed by riders aged 11-20 years, with a mean annual riding time of 259 hours/year (Rodgers 1994). Riders over 50 years of age recorded the lowest mean annual riding time, with 103 hours/year.

Riding practices according to location differed little from that reported by researchers utilizing hospital and non-hospital based data. Rodgers (1994) categorized the location of riding into six categories: sidewalks or playgrounds, neighborhood streets with low traffic volume, major thoroughfares or streets with high traffic volume, bike paths (separate from roads), unpaved roads, and other paved surfaces or trails. The proportion of time reported by bicyclists riding in these locations is an approximate, as some respondents reported they rode "more than half of the time" in more than one category -- which of course, is not possible (Rodgers 1994). Nonetheless, the majority of cyclists

(64.1%) reported that they "always" or "more than half" of the time rode on neighborhood streets with low traffic volume, accounting for 58.1% of the total reported riding time. Sidewalks or playgrounds were the next most commonly reported riding place, accounting for 29.2% of those cyclists who "always or more than half" of the time rode in these areas, and 32.3% of the total reported riding time responses. Conversely, the leading locations for the least popular riding location included "major thoroughfares or streets with high traffic volume," and "other unpaved surfaces or trails" (Rodgers 1994). Rodgers (1994) noted that 93% of the respondents reported that they rode on "major thoroughfares or streets with high traffic volume," and 89.2% of the respondents reported that they rode on "other unpaved surfaces or trails" less than half of the time or never (Rodgers 1994). These percentages corresponded to 91.3% and 84% of the total riding time reported by respondents.

The proportion of cyclists "riding after dark" was also assessed by Rodgers (1994). An overwhelming majority of respondents reported that they did not ride after dark. Approximately 96% (96.4%) of riders stated they never rode, or rode less than half of the time after dark, accounting for 95.2% of the total reported riding time.

Respondents' helmet usage practices were also surveyed. Several important patterns were associated with an increased likelihood of helmet use. Among those respondents who reported wearing a helmet "all or more than half of the time," helmet use was found to be positively associated with riding time, household income, education, males, and age to some extent. Approximately 21% (20.8%) of those respondents who reported riding ≥ 100 hours/year, compared to 18.2% and 11.7% of those respondents who reported riding 25-99 and < 25 hours/year, respectively, wore helmets "all or more than half of the time." Similarly, 29.1%, 18.1%, 16.3%, 13.6%, and 13.6% of riders from households with incomes of ≥ $60,000, $45-$59,900, $30-44,900, $15-$29,900, and < $15,000, respectively, reportedly wore helmets "all or more than half of the time" (Rodgers 1994).

Like household income, education was also positively associated with helmet usage. The "highest level of education attained by a household member" was reported by Rodgers (1994, p. 92). Rodgers noted that rider households with a member who was a college graduate was approximately 3 times more likely than rider households whose members only had a high school education or less. The corresponding percentages among riders who stated that they "always or almost always" wore a bicycle helmet while riding were: 22.8% for riders households with a college graduate, 18% for rider household with a member having had some college, and 7.5% for rider households with members whose highest level of education attained was a high school degree or less.

Surprisingly, males reported wearing a helmet "always or almost always" more often than females, 19.3% versus 15.7%, respectively. The age of riders donning a helmet "always or almost always" was less of a surprise. Rider respondents aged 41 years or more, were most likely to report wearing a helmet "always or almost always," (47.7%), compared to those aged 21-40 years (38.2%). Riders 20 years of age or less, were least likely to report wearing a helmet "always or almost always," (29.4%), with riders aged

11-20 years reporting the lowest regular usage (12.4%).

The final profile addressed in Rodgers' 1994 manuscript concerned the bicycle itself. Rodgers (1994) reported that 80.6% of all respondents stated that they had purchased their bicycles new, although only 38.8% felt that the status of their bicycle at the time of the survey was "like new." Taillights and headlights were the most commonly reported bicycle accessories, but were recounted by only 20.6% and 14.5% of respondents, respectively.

Rodgers (1994) believed that, "Injury studies provide valuable information about injury characteristics and scenarios, but in the absence of exposure data they are not sufficient to determine and quantify the factors associated with risk" (p. 84). Rodgers further noted that lack of acknowledgment of, or failure to gather National exposure or control data (such as types of bicycles, riding times, years of riding experience, and riding locations), for comparison with reported injury and fatality studies, results in inappropriate systematic conclusions and subsequent decisions based on incomplete information. Fittingly, Rodgers (1994) provided the following example to illustrate his point:

> The National Highway Traffic Safety Administration (1993) reports that about 35.1% of bicyclists deaths in 1991 occurred after dark. In contrast, the bicycle survey results indicate that only about 12.4% of all bicyclists engaged in nighttime riding; moreover, about three-quarters of those who reported nighttime riding said that they rode after dark less than half the time. The relatively large proportion of deaths that occur after dark, compared with the relatively small proportion of

> riding that takes place after dark, shows that nighttime riding is an important contributing factor in bicyclists deaths" (p. 94-95).

This author agrees with Rodgers' (1994) viewpoint and hopes that this manuscript provides additional support for the comprehensive review and synthesis of this body of literature, especially in reference to bicycle helmets.

The second manuscript published by Rodgers (1995) utilizing the results from the same National survey described above, focused specifically on factors associated with helmet use, including helmet selection, and helmet usage patterns. Helmets were owned by approximately 27.3% of all riders. Of those that owned bicycle helmets, hard shell helmets predominated (77.9%), with soft shell helmets lagging behind at 14.1%, followed by thin shell helmets (5.1%). Among helmet owners, helmet usage proportions were recorded accordingly: 48.9% "always or almost always" wore them, 15.3% wore them "more than half of the time," 21.8% reportedly wore them "less than half of the time," while 13.5% stated that they "never or almost never" wore their helmets (Rodgers 1995). Using these proportions, Rodgers (1995) estimated that approximately 17.6% of all bicyclists wore their helmets "all or most of the time," 6% wore them "less than half of the time," compared to 76% of all bicyclists who "never or almost never" wore helmets. Unique to Rodgers' (1995) study was a detailed, yet organized, assessment of the factors influencing the helmet usage patterns of its respondents. The responses were categorized accordingly: 1.) prior helmet usage practices, as noted above ("always or almost always," "less than half of the time," or "never or almost never)," and 2.) age of the rider (less than 16, greater than

16, and all riders). Among the riders who reportedly wore their helmets "always or almost always," 97.8% did so for safety reasons. Family member insistence was a significant factor for 93.1% of children less than 16 years. A legal requirement mandating helmet use appeared to be the least influential factor in the decision to wear a helmet. Only 13.5% of all riders, and 11.5% of children less than 16 years who stated they "always or almost always" wore a bicycle helmet agreed that a local legal requirement to wear a bicycle helmet, was an important reason for their doing so.

Examination of those bicyclists who reportedly wore their helmets some of the time ("less than half of the time," or "more than half of the time") revealed that 40% of all riders stated they wore their helmets when riding in traffic, with children under the age of 16 donning a helmet only 29.5% when riding in traffic. Teenagers and adults 16 years of age or older reportedly wore their helmets more frequently than those under the age of 16 when "on long rides," "remembering to," and when "riding with family members." Children under the age of 16 surpassed those aged 16 or older in response to only one question, "when reminded," with a percentage of 29.7% versus 9.1% respectively. When questioned why they did not wear their helmets, children less than 16 in this category of cyclists responded "they forgot," most often (24.2%), followed by "when not riding in traffic" (19.5%), and "when riding a short distance" (18.9%). In comparison, cyclists over the age of 15 reported that they most often did not wear a helmet "when riding a short distance" (41%), followed by "when not riding in traffic" (27%). Correspondingly, the single most often cited reason for not wearing a helmet by all those who originally reported that they wore a helmet "less than half of the time," was when "they were riding a short distance (31.6%).

Lastly, among the bicycle riders that stated that they "never or almost never" wore a helmet, the three most frequently cited reasons did not differ by age. Both children less than 16 and those 16 years and older stated: 1.) "never thought about it" (19.1% and 23.6%, respectively), and 2.) "helmet are unnecessary" (17% and 24.1%, respectively), and 3.) "seldom ride in traffic" (19.4% and 18.4%, respectively). In addition, 15.6% of all riders in this category stated that they had not yet purchased a helmet.

Subsequent to organizing all of the participants responses, Rodgers (1995) used a probit regression model to identify those characteristics and patterns most associated with helmet use. Rider characteristics, bicycle use patterns, and household demographic factors

were all considered. Three different statistically significant models were found to be predictive of whether a rider would wear a helmet. Rodgers (1995) considered respondents who reported that they wore helmets "always or almost always" or "more than half of the time," to be helmet wearers. Several relationships were noted. Results of the regression indicated that bicyclists were more likely to wear a helmet if riding on major thoroughfares, or on bike paths, versus those who rode on neighborhood streets and low traffic streets. The likelihood of helmet use also increased with riding time, especially for older riders. Gender and rider experience was noted to be slightly related to helmet use, but the relationship is complex. Notably, helmet use was also found to be positively associated with education, and location in Pacific Coast states. Bicyclists residing in the

Midwest, Southern or Mountain states tended to be less likely to don a helmet in comparison to those residing on the Pacific Coast.

A few additional associations were noted upon further statistical manipulation of the data. Bicyclist who rode approximately 100 miles or more a year, were noted to be 75% more likely to wear a helmet when compared to those who rode less than 25 hours per year. Likewise, bicyclists who rode on major thoroughfares or roads with a high traffic volume and those that rode on bicycle paths were approximately two times more likely to wear a helmet when compared to those who rode on unpaved surfaces, neighborhood streets, or sidewalks/playgrounds.

Although the findings of Rodgers' (1995) studies provide a great deal of insight into results obtained from earlier studies, one important consideration is the potential for distorted answers from respondents. Barnett (1991) notes that respondents have a tendency to provide misinformation for various reasons, including but not limited to, self-protection, self-esteem, or a willingness to appear to be doing the right thing. This may have been a confounding factor in Rodgers' (1995) study especially when parents were asked to complete the survey for children less than 16 years. The parent or guardian may not have known the actual answer, or may have been told the response they expected to hear from their child.

A few earlier studies collected National data using a different methodology and targeting a different sample population (McLennan, McLennan & Ungersma 1988; Wasserman and Buccini 1990; Runyan et al. 1991). McLennan et al. (1988) documented the injury patterns of competitive cyclists participating in 10 USCF endorsed races above 1500 meters in altitude, from 1983 through 1986. This permitted comparison of injury patterns pre and post the 1986 USCF ruling mandating helmet use by competitive cyclists during both training and racing conditions. Fifteen hundred senior category cyclists participated in the 1986 survey, while 3900 senior category cyclists completed the survey throughout the period 1983-1985, thereby comprising the comparison group. The number of accidents fluctuated over the four year period, with 1985 having the highest number of reported injuries (3,5%) and 1986 the lowest (1.5%). Twenty-three accidents (1.5%) occurred during 1986, all of which resulted from falls. Over 60% of the accidents from 1983-1986 occurred during criteriums, as opposed to during road races. The cyclists' level of experience was a pivotal factor related to the probability of injury, with inexperienced riders comprising 75% of the accidents. Not surprising, "pile-ups" of 4 or more riders were not uncommon.

Abrasions were the major injury type by far, accounting for 48% to 51% of all injuries each year, and 49% of all injuries over the course of the study (McLennan et al. 1988). Fractures were the second leading type of injury comprising 19% to 21.5% of all injuries each year, and 20.2% of all injuries throughout the duration of the study. Head injuries ranked 5th on the list of 6 injury patterns, comprising 0% to 8.7% of all injuries each year, and 6.2% of the total injuries documented over the course of the study. McLennan and associates (1988) reported that prior to 1986, only 12% of all cyclists wore approved bicycle helmets during competition. In comparison, 100% of all racing cyclists wore a helmet in 1986, which reduced the number of reported head injuries to zero during that year. However, McLennan and colleagues (1988) discerning commented that prior to 1986 medical coverage during competition was barely adequate, with treatment frequently being inappropriate and delayed. Specifically, fractures were reportedly not diagnosed (26%), or were inappropriately immobilized (85%), and 65% of head injured victims were permitted to continue racing (McLennan et al. 1988). The administration of unsuitable medical care and advise was rectified judicially in 1986, with the instillation of regulation requiring a physician to be present during all races.

Wasserman and Buccini (1990) sought to determine the efficacy of bicycle helmets in the prevention of head injuries from the perspective of the avid cyclist. These researchers polled the readers of four popular bicycling magazines via a letter submitted by Buccini inquiring about head injuries resulting from bicycling accidents. Thus, the focus of their study was on bicycle-related head injury. Two hundred ninety-seven readers responded, and subsequently completed a questionnaire detailing their accidents. The majority of respondents were 40 years of age or older (39.1%), with only 7.6% younger than 20 years of age. The number of males surpassed females 66% to 34%. Age-sex specific injuries were not reported.

Helmet use at the time of the accident, was found to be most prevalent among males (67.6%), and cyclists aged 40 years and older (44.8%), more so than any other age group (Wasserman and Buccini 1990). Cyclists under the age of 20 years comprised the lowest group of helmet wearers (2.9%), while approximately 26% of each of the middle two age groups (20-29 years and 30-39 years) recalled that they were wearing helmets at time of their accident (Wasserman and Buccini 1990).

As one might anticipate from the focus of the survey, the number of head injuries surpassed all other types of injuries, accounting for 27.5% of head and neck injuries among helmet wearers and approximately 63.4% of similar injuries among non-helmeted riders (Wasserman and Buccini 1990). More specifically, concussions were reportedly sustained by 26.6% of helmet wearers, versus 50% of non-helmet wearers. In contrast, extremity injuries comprised only 14.7% and 4.9% of concurrent injuries below the neck in helmet wearers and non-helmet wearers, respectively. Although this study may provide some credence to the concept that helmets afford protection to bicyclists, the target population being those who sustained bicycle-related head injuries, surely over-estimates the prevalence of these injuries in the population at large.

Wasserman and Buccini (1990) also sought to identify who, or what, was cited as responsible for the bicycle accidents reported. Among the cyclists surveyed, 23% cited poor road conditions, 12% stated they lost control of their bicycle, and 8% maintained that they were attempting to avoid an animal when the accident occurred. Bicycle-motor vehicle collisions were reported by 22% of all respondents.

Like McLennan and colleagues (1988), Runyan and associates (1991) were interested in the effect of the USCF 1986 policy mandating helmet use for all racers, both in training and during competition. However, the methodology used by Runyan and associates (1991) differed slightly from that of McLennan and colleagues (1988). Runyan and associated gathered data from a random sample of competitive cyclists through the use of a self-administered questionnaire. The questionnaire was designed to assess bicycle helmet use and attitudes, along with compliance with the 1986 USCF mandatory helmet policy. A simple random sample of 770 United States Cycling Federation (USCF) members were mailed a questionnaire, and reminder post-cards three weeks post the original mailing. A second letter and questionnaire was sent to non-respondents five weeks post the original mailing. A final response rate of 72% was noted, with 554 completed questionnaires. The age of respondents ranged from 11 to 81 years, with a mean age of 27 years. Cyclists reportedly averaged 198 miles per week, excluding racing miles. Detailed data regarding helmet use and injuries was not provided by the authors. A nonspecific table with odds ratios was provided, but made comparisons with attitudes towards helmets and helmet usage patterns difficult. With this in mind, Runyan and associates (1991) noted that the odds of head/face injury using no helmet versus a hard shell helmet was 6.7:1. In comparison, the odds for no helmet versus leather helmets and leather helmets versus hard shell helmets were 1.9:1 and 3.6:1, respectively.

Review of the published responses indicated that 306 (56%) respondents recalled entanglement in an accident that resulted in "hitting of the head or face." Of these 306 cyclists, 59.8% reported sustaining head or facial injuries. The perception of the possibility of injury among competitive cyclists varied according to racing and training conditions. Although 93% of all respondents reported having been involved in a crash, 80% felt that a crash was "at least somewhat likely" in a race, compared to only 41% who considered a crash to be "at least somewhat likely" during training. Moreover, only 20% of the 90% of all respondents reported that they had owned a helmet prior to the USCF mandatory helmet policy.

Surprisingly, competitive cyclists' views on cycling safety and the importance of helmets varied little from those of the general community. Competitive cyclists ranked "use of a hard shell helmet" seventh in importance behind various groupings of attentiveness to road traffic safety rules and situations, and proper maintenance of the bicycle. Furthermore, although 91% of the cyclists believed that hard shell helmets could prevent head injury, 71% felt they were worth their price, 54% felt they both looked funny and felt heavy, 45% commented that they were uncomfortably hot, 31% believed that they "detracted from the tradition of bike racing," 24% considered them "uncool," and 14% felt they caused neck injuries (Runyan et al. 1991). Interestingly, only 36% thought "they made cyclists more visible to motorists" (Runyan et al. 1991). While it is not startling that the use of racing helmets increased from 47% to 90% post USCF ruling, it is surprising that 58% of the respondents reported that they did not modify their helmet use following the ruling. Moreover, an unreported "small minority" of respondents agreed with the statement, "All cyclists should be required to wear hard shell helmets at all times in all cycling situations." (Runyan et al. 1991, p. 234).

In contrast to the authors, I am not convinced that the "spill-over" effect noted under racing conditions would apply to the general public should mandatory helmet legislation be passed. Among the competitive cyclists who completed this questionnaire, more than half stated that they did not modify their helmet use post the 1986 policy mandating them to wear a helmet in training as well as during racing. Moreover, only 20% of the respondents felt helmets should be mandated in all situations (focus was on training situations), while 47% favored voluntary wearing of helmets. The fact that competitive cyclists report they do not comply with helmet policies mandated from their professional organization, for varying reasons, is suggestive that their effectiveness has not been shown to be overwhelming beneficial or that problems in their design prohibit their acceptance. This is a significant abstraction in itself. If professional cyclists who typically train on roadways with motorists traveling at high speeds, thereby placing them in the situation most prone to bicycle-related head injuries in the event of an accident (i.e., bicycle-motor vehicle collisions), do not overwhelmingly acknowledge the need for bicycle helmets, it would appear to signify that advocates of helmet use may not, as Rodgers (1994) implied, have enough information to make decisions on a systematic basis. Possibly, bicycle helmets, like child snow-suits, may be beneficial in the prevention of injury (head injury versus severe frost-bite), but should they be mandated with fines levied on those who do not, or cannot, afford to comply.

As noted above, a concern with all interviews and questionnaires is the potential for respondents to misrepresent themselves, or falsify information. Accordingly, caution should be used in any and all inferences made from the studies just presented. However, their information should not be ignored. Rather, integrating their results with those from hospital and surveillance system data, may provide the missing link to uniting helmet advocates and opponents.

Regional Injury Profiles

Regional observational and survey studies varied according to location, purpose, and subject population. Assessment of each of the studies was performed on the key issues noted above, as appropriate, with the addition of a "professional involvement" section. This section, like that of avid and professional cyclists, was added to provide insight regarding the perceived importance of bicycling helmets among some members of the medical community. The subject populations of the following studies differed from one another, but four collective aims prevailed among the studies: assessment of bicycle accidents and injuries, helmet practices, effectiveness of legislation, and professional involvement.

Population Specification and Age and Gender Patterns

The safety of the high-rise bicycle, a style of bicycle with a "banana seat," a vertically projected elongated handle bar, and a front tire that is smaller than the back, was the focus of the 1971 study conducted by Waller. The popularity of the high-rise bicycle in the late 1960's and early 1970's was postulated to be associated with an increased number of bicycle accidents. Children aged 12 years and younger participated in the study. Subjects and data were acquired from four different sources: 1.) 380 consecutive individuals registering their bicycles at the Burlington Police Department in Vermont, were asked to complete a questionnaire containing information regarding bicycle ownership, injuries and style preferences. 2.) Kindergarten through six grade public and private school students were interviewed on information similar to that requested in the questionnaire administered to individuals registering their bicycles. Subsequent to the interview, the interviewer went to the neighborhoods surrounding each of the public schools and evaluated the frequency with which owners of different styles of bicycles rode their bicycles. 3.) Emergency room records from the regional medical center were reviewed for all children aged 3 through 12 years who sustained a bicycle-related injury between June 15 and October 14, 1969. The nature, cause and associated factors of all injuries were evaluated, with a follow-up interview conducted with the each child's mother. 4.) Age, sex, and neighborhood matched controls were found for all children sustaining bicycle-related injuries. The same questions as those asked of case mothers were asked of control mothers, as appropriate.

The various data sources used in this study revealed that 6185 children owned bicycles in Burlington and South Burlington, Vermont. Of those, 3267 (52.8%) were males and 2918 (47.2%) were females. Standard bicycles were owned by 52.2% of all males, and 76.8% of all females, in comparison to 43.1% males and 21.7% females who owned high-rise bicycles. Both standard and high-rise bicycles were owned by 4.7% of all males and 1.5% of all females. Males experienced 71% of all injuries regardless of bicycle style. Among owners of standard bicycles, males sustained 65.8 % of all injuries. In contrast, males sustained 77.4% of all injuries among high-rise bicycle owners. Children aged 5-9 years were noted to have the highest incidence of injuries when compared to children 10-12 years of age.

The same area of the country, Burlington, Vermont, was the cite of a subsequent study conducted by Wasserman and associates (1988), who attempted to interview cyclists roadside. Interviewers were stationed at various strategic locations during daylight hours, and sought to query cyclists over the age of 10 years, as they road by. The cyclists willing to participate had a mean age of 23.4 years, and were comprised of 64.4% males.

In a design similar to Wasserman and associates (1988), Fullerton and Becker (1991) aimed to determine the bicycle and helmet use patterns of students at the University of New Mexico, during the 1988 Fall term. Interviewers were located near the student union building of the campus, and reportedly approached students near that facility to identify potential candidates to complete the bicycle survey. Viable subjects were screened to determine enrollment in the University and whether they rode a bicycle in Albuquerque (Fullerton and Becker 1991). Only those students who answered both questions positively were asked to complete the bicycle questionnaire used in the study. The selection process used to identify students was not specified. All students who owned bicycles reportedly agreed to complete the questionnaire. A total of 100 cyclists participated. Among those, 61% were males, and all were 18 years of age of older. Subjects aged 18-20 years and 21-24 years comprised the largest proportion of cyclists, accounting for 31.5% and 33.7% of all respondents, respectively. In comparison to women, men reportedly sustained more total injuries, minor injuries, and multiple minor injuries in a period of one year. Conversely, females reportedly incurred more hospitalizations due to bicycle-related accidents. Fullerton and Becker (1991) noted this injury pattern corresponded to a rate of minor injuries during the previous year that was 1.6 times higher for men, when compared to women.

The attitudes of school-age children regarding bicycle helmets, were the focus of an article published by DiGuiseppi and associates (1990). Questionnaires were mailed to the parents of third-grade students in the Seattle, Washington area during the 1986-1987 school year. All subjects were randomly selected, among those enrolled in the Seattle public school system. Third grade students were chosen because they would be the target of an area bicycle helmet campaign to begin in 1987. Follow-up post cards were mailed two weeks post the original mailing, with a second questionnaire mailed to all non-responders two weeks later (DiGuiseppi et al. 1990). A total of 2178 questionnaires were randomly sent to the parents of 3231 third graders. Of those mailed, 1057 questionnaires were completed and returned, for a response rate of 48.5%. The mean age of the respondents was 9.1 years, with females slightly out-numbering males 535 (50.9%) to 517 (49.1%). The gender distribution of helmet ownership was reportedly parallel.

School-age children were the focus of another study conducted by Kimmel and Nagel (1990). The relationship between children's knowledge of bicycle safety, bicycling practices and their corresponding incidence of bicycling injuries, was the subject of a brief bicycle questionnaire administered to 4th through 8th graders in Lucas County, Ohio, an upper middle class suburban community. A total of 276 out of 300 questionnaires were returned, for a response rate of 92%. Students ranged in age from 9 to 15 years, with the majority of respondents (96%) aged 10-14 years. Reportedly, respondents were equally distributed among the grade levels, with boys comprising 53% of the total respondents.

The remaining studies surveyed avid or professional cyclists, in an attempt to gain insight into the nature of bicycling injuries and helmet use among more experienced riders. A study of urban cyclists was conducted by Sgaglione and associates (1982) to identify factors related to urban bicycling accidents. Manhattan cyclists were selected from among participants in two area bicycling races. Only those participants who cycled more than 5 miles per week, and had been cycling in Manhattan six months or longer were chosen, to ensure adequate urban cycling experience (Sgaglione et al. 1982). A total of 193 bicyclists completed the questionnaire, but only 93 met both inclusion criteria. The mean age of all cyclists was 25.25 years, with males exceeding females 79.5% to 20.5%, respectively. Subjects aged 15-34 years comprised 81% of the total sample, and 80% of all accident victims, with 25-34 year olds, accounting for the largest percentage of accidents (45%). Typically, males sustained a greater number of injuries than females. However, Sgaglione and associates (1982) noted that males accumulated far more cycling miles than their female counterparts.

Analogous to Sgaglione et al. (1982), Kiburz and associates (1986) mailed a survey to 807 bicyclists procured from members of two cycling clubs in Kansas and participants in an area bicycling ride. Of the 807 surveys mailed, 492 were completed and returned (61%). Respondents ranged in age from 6 to 86 years, with a mean age of 34.3 years. Males bicyclists exceeded females, 65% to 35%, respectively. Interestingly, Kiburz and colleagues (1986) noted that although males accumulated more mileage, were more experienced, were more likely to experience a bicycle accident, and used helmets more frequently, it was females who were more likely to sustain serious injuries as a result of a bicycle accident.

Using the same type of medium, but different focus, Chow and colleagues (1993) mailed surveys to members of two California cycling clubs that encouraged all-terrain cycling. Chow and colleagues (1993) aimed to assess the type of injuries sustained by all-terrain riders, rather than the typical road cyclist. Of the 459 surveys mailed, 268 were completed. The cyclists ranged in age from 14 to 68, with a mean of 36.2 years. Males overwhelmingly outnumbered females 82.8% to 17.2%, which reportedly accurately reflected membership proportions.

Location and Type of Injury Data

The nature of injuries reported appeared to vary among studies. Differences were noted among studies whose emphasis was the examination of all bicycle-related injuries, versus studies whose primary interest was the assessment of the effectiveness of bicycle helmet and head injuries. This analysis of injury documentation is not new, rather it is consistent with those studies previously reviewed. Four groups of researchers surveyed four different samples of cyclists in an attempt to identify the types of accidents and injuries most commonly incurred (Waller 1971; Sgaglione, Suljaga-Petchel 1982; Kiburz, Jacobs, Reckling & Mason 1986; Chow, Bracker, & Patrick 1993). Of foremost interest to Waller (1971) was whether the bicyclist riding the then popular high-rise bicycle more prone to bicycle-related injuries than riders of the traditional style bicycle. Recall that various samples of children aged 12 years and younger were asked to complete the study questionnaire. The reported injuries included approximately 67% abrasions, lacerations and contusions, 20% fractures, and 5% concussions (Waller 1971). No significant difference was noted in the severity of injuries between riders of the traditional style and high-rise style bicycles.

A similar pattern of injuries was described a decade later by researchers studying avid and professional cyclists (Sgaglione et al. 1982; Kiburz et al. 1988; Chow et al. 1993). Sgaglione and colleagues (1982) revealed that 49 (52.7%) of their respondents reported experiencing a bicycle-related injury. The severity of those injured consisted predominately of minor injuries (55%) which required no medical attention, followed by moderate injuries - those injuries requiring emergency room treatment or the services of a physician (31%), and a small percentage of serious injuries (6%), which precipitated hospitalization (Sgaglione et al. 1982). Eight percent of all respondents reported that they had experienced no injuries. Among those injured, 92% reported sustaining an injury as a result of their last bicycle accident. Abrasions and lacerations were the leading cause of injury (64%). Sprains and strains were the next most frequently reported injury (15%), proceeded by fractures (12%) and concussions (9%). The extremities were the cite of most injuries (64%), with upper extremities accounting for 38% of all extremity injuries. The head and face region sustained 25% of all injuries, followed by injuries to the trunk (11%).

Similar to the results of Sgaglione and associates (1982), Kiburz and colleagues' (1986) respondents overwhelmingly reported contusions (56.8%) and lacerations (42.7%)

as the most frequently experienced type of injury. The remainder of the injuries, by type, consisted of fractures (14.1%), sprains (10.1%), concussions (8.8%) and internal injury (2.6%). The majority of cyclists reported experiencing no injuries (10.6%), or mild injuries (54.6%) requiring no medical treatment. In contrast, 23.8% of those injured reported moderate injuries, or those requiring medical attention, and 11.0% reported sustaining injuries serious enough to warrant hospitalization. Once again, extremity injuries prevailed as the leading cite of injuries, with upper extremities accounting for 85.1% of all injuries, and lower extremities accounting for 72.1% of all injuries. Head injuries were recollected in 16.7% of all injuries, although only 8.8% were serious enough to be diagnosed as a "concussion" (Kiburz et al. 1988).

Unlike the previous studies, Chow and colleagues (1993) aimed to evaluate the type of injuries sustained by mountain bicyclists. Eighty-four percent of all respondents reported experiencing a minimum of one injury while participating in all-terrain cycling. Extremity injuries were the primary type of injury, comprising 89.3% of all injuries, followed by trunk injuries (37%). Head and neck injuries accounted for 12% of the injuries. The majority of injuries were mild in severity, requiring no treatment (21.8%) or self-treatment (48%). Of the remaining patients, 14.6% sought medical treatment in an emergency room, (11.4%) received treatment in a physicians office, while 4.4% required hospitalization.

In contrast to those studies whose principle aim was to document the type and severity of injuries sustained by cyclists, other investigators sought to determine the effectiveness of bicycle helmets in the protection against head injuries (Wasserman, Waller, Monty, Emery, & Robinson 1988; Fullerton & Becker 1991). Wasserman and associates (1988) conducted roadside interviews in Vermont of individuals over 10 years of age. Five hundred-sixteen of 683 (76%) consented to participate in the interview. Helmet use was observed for 7.8% of all subjects, although 18.8% reported owning a helmet. Despite the low helmet use, only 21 (4.4%) stated that they had been involved in a bicycle accident that included striking their head. Of these, only 7 (1%) sustained minor head injuries serious enough to warrant medical attention: 3 concussions and 4 lacerations requiring sutures (Wasserman et al. 1988).

Fullerton and Becker (1991) queried university students about bicycle-related accidents and attitudes toward helmets at the University of New Mexico. One hundred students responded to the questionnaire. Among those, 18% revealed that they had been hospitalized at some time due to a bicycle-related injury. Forty-four percent reported sustaining a minor bicycle-related injury during the last year, and 65% during the last 5 years. Head injury reportedly accounted for 9.1% of all injuries in the last year, and 13.8% of all injuries during the previous 5 years. Only one head injury in the previous 5 years was incurred while wearing a helmet (7.1%), in comparison to none in the previous year. The table of bicycle-related injuries provided by the authors was a bit confusing. The denominator used in the calculation of various percentages ("head injuries," "injuries sustained while wearing a helmet," and the percentage of "head injuries while wearing a helmet") was not clearly defined, but could be extrapolated with assistance from the authors' discussion.

The greater percentage of reported minor injuries in studies utilizing observational/survey methodology, especially abrasions and lacerations, may provide a more accurate reflection of their actual occurrences. The minor nature of such injuries potentially precludes many bicyclists from seeking medical treatment, which may account for their under-representation in the previously reviewed hospital-based studies.

Race and Socioeconomic Considerations

Both studies conducted by Waller (1981) and Wasserman and associates (1988) were conducted in Burlington, Vermont, a predominately white urban community. Socioeconomic factors were briefly addressed by Wasserman and associates (1988) who noted that among the cyclists they interviewed, 43% had more than a high school education, 43% received between 13-16 years of education, and 14% had greater than 16 years of education. The proportion of cyclists wearing helmets appeared to be positively associated with years of education. Accordingly, the highest percentage of helmet wearers (20.8%) were among those who acquired greater than 16 years of education. The positive relationship between years of education and bicycle helmet ownership was also noted by DiGuiseppi and colleagues (1990). Using slightly different partitions for level of education, DiGuiseppi and colleagues (1990) found that 5.7% of parents with less than or equal to 12 years of education, 18.5% of parents with 13-15 years of education, 27.5% of parents with 16 years of education and 42.9% of parents with greater than 16 years of education, reportedly owned bicycle helmets. Corresponding helmet purchases for their children by parental level of education, reportedly were 18%, 15%, 21% and 38%, respectively.

Racial disparities were documented by Fullerton and Becker (1991) in their survey of cyclists at the University of New Mexico. Among the 100 cyclists interviewed, 69.7% were White, 19.2% Hispanic, 3.0% Native American, 2.0% Black, and 6.1% were listed as other. Among each ethnicity, 37.7% of Whites, 5.8% of Hispanics, and 0% of both Native Americans and Blacks respectively, reportedly owned a bicycle helmet. Racial-specific patterns of bicycle-related injuries were not documented. The remainder of studies previously addressed, but not mentioned here, did not reported racial and socioeconomic differences in their manuscript.

Time of Day/Week and Seasonal Variations

Time of day/week and seasonal variations in the occurrence of bicycle-related injuries were only documented by those researchers studying avid and professional cyclists. Bicycle accidents in the sample population over-whelmingly occurred during daylight hours (Waller 1971; Sgaglione et al. 1982; Kiburz et al. 1986; Chow et al. 1993;). Sgaglione and associates (1982) reported that 79% of all urban bicycle accidents occurred during the daytime. Kiburz and colleagues (1986) identified the hours between 2 and 5 PM as the most prevalent time period reported for bicycle accidents among their respondents (42.5%). Chow and associated (1993) concurred with the above findings noting that 63.1% of all reported all-terrain bicycle accidents occurred mid-day.

Bicycle accidents were also most common during the summer months (Sgaglione et al. 1982; Kiburz et al. 1986; Chow et al. 1993;). Sgaglione and associates (1982) found that 70% of all urban bicycle accidents recorded in their study occurred between June and September. Likewise, Kiburz and colleagues (1986) noted that bicycle accidents were most prevalent between May and August, encompassing 69.6% of all accidents. Similarly, Chow and associates (1993) identified June and July as the most common months for the occurrence of bicycle-related injuries.

Weather Conditions

Adverse weather conditions were not identified as a significant contributing factor to many bicycling accidents. Chow and colleagues (1993) noted that 89.3% of all-terrain bicycle accidents happened on clear days.

Location and Collision Type

In the examination of bicycle accidents among children less than 13 years of age while riding either high-rise or standard bicycles, Waller (1971) noted that most injuries occurred as a result of contact with the ground. In contrast, the more serious injuries (concussions and fractures) were reportedly sustained following contact with an object other than the bicycle itself (Waller 1971). Standard bicycles were found to be involved in a greater number of bicycle accidents with automobiles than high-rise bicycles. Road conditions did not appear to contribute significantly to the cause of the children's accidents, as approximately 70% occurred while the bicyclists were riding on smooth road surfaces.

Unlike Waller (1971), Sgaglione and associates (1982) assessed the injury patterns of experienced adult urban cyclists. They noted that 65% of all bicycle accidents occurred on the street, versus 21% while racing and 14% on bicycle paths. Motor vehicles were involved in 41% of the reported bicycle accidents. Bicycle collisions with other bicyclists and pedestrians accounted for 16% and 12% of all reported accidents, respectively. Bicyclists were alone at the time of the accident 31% of the time. Similar to Sgaglione and associates (1982), Kiburz and colleagues (1986) examined the injuries resulting from bicycle accidents sustained by adult cyclists in Kansas. Most injuries (80.3%) occurred on streets, and during recreational rides (95.3%). Only 22.8% of all bicycle accidents happened under racing conditions. Motor vehicles were involved in 20.8% of all bicycle accidents, which is almost half the proportion noted by Sgaglione and associates (1982). As anticipated, Chow and colleagues (1993) found disparate results from the other researchers in their examination of all-terrain cyclists. Chow and colleagues (1993) noted that 87.6% of all injuries occurred on off-road surfaces, rather than on paved terrain. Falls accounted for the largest percentage of all-terrain injuries, with collisions with motor vehicles associates with one of the fewest percentages of injuries (approximately 2.2%).

Assignment of Fault

Inexperience (including loss of control, spatial misperceptions of other objects, distraction, and panic) and horseplay were the leading causes of childhood bicycle accidents in the study conducted by Waller (1971). In addition, non-familiarity with the bicycle was attributed to approximately 37% of all the bicycle accidents, due to children riding a bicycle other than their own (Waller 1971). Appropriately, lack of road traffic safety was the emphasis of the study performed by Kimmel and Nagel (1990). School-age children were questioned regarding their understanding of 3 essential bicycling rules: 1.) A bicyclist should ride on the right side of the street, with traffic, 2.) A bicyclist should always stop at a stop sign or red light, and 3.) A bicyclist would always stop before entering the street from a driveway or alley (Kimmel and Nagel 1990, p. 678). Nearly one quarter (24%) of all children were unaware of which side of the street they should ride on, while 13% did not know that they were always required to stop at stop signs and red lights. However, the largest percentage of children (29%) were incognizant of rule number three. Coincidentally, whether or not students were knowledgeable of rule number three, resulted in a statistically significant difference among bicyclists who were recently involved in an accident causing damage to their bicycle. Likewise, unawareness of rule number three was also significantly related to being injured in a bicycle accident that required medical attention (Kimmel and Nagel 1990). No apparent age-gender pattern regarding bicycle knowledge was noted.

In contrast to hospital based studies and related studies that utilized medical data for the average bicyclist, observational and survey data of the avid and professional cyclist implicated a greater a number of adult cyclists as responsible for their bicycling accident (Sgaglione et al. 1982; Kiburz et al. 1986). Sgaglione and associates (1982) found that among the urban cyclists in their study who experienced a bicycle-related accident, 53% stated they were not at fault, while 47% felt they were responsible for their accident. Motorists were implicated in 26% of the accidents, while poor road conditions (potholes and wet roads) contributed to 22% of the accidents. Environmental conditions (wet roads and poor visibility) were documented as contributing factors in 18% of all bicycle accidents. A moderate percentage of cyclists (36%) attributed failure to follow traffic rules and careless cycling (25%) as pertinent factors in the cause of their bicycling accident.

Comparable to Sgaglione and associates (1982), the cyclist considered himself at fault in 58.7% of all bicycle accidents, while motorists were cited 17.5% of the time, in the study conducted by Kiburz and colleagues (1986). Environmental conditions such as road debris, railroad tracks and rough roads, were viewed as contributing factors in 36.9% of all accidents. Bicycle maintenance problems were perceived to be an associated factor in 14.9% of all recorded bicycle accidents.

A large percentage of the all-terrain accidents reviewed by Chow and associates (1993) involved cyclist error. Among those injured, 36% felt excessive speed may have contributed to their accident. Unfamiliar terrain was cited in 34.7% of all accidents, and inattentiveness and "riding beyond their ability" was cited in 22.7% and 19.6% of the all-terrain accidents, respectively (Chow et al. 1993). However, the nature of all-terrain cycling requires a different level of experience and ability than road cycling. The disparity between road surfaces and environmental conditions alone, dictates a greater ability and experience level for safer all-terrain cycling. Thus, making fault comparisons with road cycle accidents may not be appropriate.

Helmet Usage Patterns

Helmet use varied according to age, location, and the type of cyclist (recreational or avid/professional). Contrary to what was noted in the above studies utilizing hospital acquired data, a small percentage of urban cyclists from a well-educated, primarily white community were observed wearing a bicycle helmet during a roadside interview of cyclists (Wasserman et al. 1988). However, as is typical of all cyclists, a larger percentage of cyclists reported owning a helmet (18.8%), than were actually observed wearing a helmet (7.8%). Short trips (28%) and the opinion that helmets were uncomfortable (24%) were the leading reason for not donning a helmet. Furthermore, despite the perceptions held by cyclists, 81.9% of all cyclists recognized that bicycle helmets are effective in reducing head injury, and that bicycle-related head injuries are serious (55.9%), 54.6% of the cyclists interviewed felt that the chance of hitting their head during an injury was unlikely (Wasserman et al. 1988).

The findings of DiGuiseppi and associates (1990) regarding helmet ownership and use paralleled those of Wasserman and associates (1988). DiGuiseppi and associates (1990) found that the following perceptions were positively associated with helmet ownership: 1.) belief in the likelihood of incurring a bicycle-related injury (OR = 2.0, with a 95% CI: 1.6, 2.5), 2.) conviction in the notion that helmets prevent bicycle-related head injures (OR = 1.6, with a 95% CI: 1.2, 2.0), 3.) having a child who had incurred a bicycle-related injury (OR = 3.1, with a 95% CI: 1.1, 8.4), and 4.) knowledge of someone who sustained a serious injury as a result of a bicycle accident (OR = 1.9, with a 95% CI: 1.3, 2.8). Unlike most other studies, the most prevalent reason cited for lack of helmet ownership by parents in this study, was never contemplating its purchase (51%). High cost (39%), the perception that the child would not wear the helmet (20%) and procrastination

(7%) were additional explanations (DiGuiseppi et al. 1990). Unexpectedly, one-fifth of all parents felt that their child did not need a helmet -- a large number in light of the major educational campaign implemented in the area.

Further examination of the children's responses to helmet use in the study conducted by DiGuiseppi et al. (1990) revealed that 56% of 223 children reported wearing a helmet during their last bicycle ride. Interestingly, the reasons children cited for not wearing a helmet differed, based upon whether or not they owned a helmet. Among children who currently owned a helmet, the most prevalent reasons mentioned for not wearing the helmet were lack of comfort (42%), forgot (35%), "friends don't wear helmets" (28%), "didn't think about it" (16%), and "don't see a need" (13%) (DiGuiseppi et al. 1990). Conversely, among the children who did not own a helmet, the reasons provided for not wearing one included "didn't think about it" (25%), "friends don't wear helmets" (25%), uncomfortable (12%), "don't see a need" (9%), and the perception that helmets are unattractive (2%) (DiGuiseppi et al. 1990). Presumptuously, disregarding the first two responses of the children who owned helmets as more applicable to helmet owners, peer pressure was the principal reason children chose not to don a bicycle helmet.

In contrast to the large percentage of school-age children who reportedly owned a helmet in the study conducted by DiGuiseppi and associates (1990, Kimmel and Nagel (1990) found that only 15 of 267 (6%) school-age children reportedly owned a bicycle helmet. Moreover, 53.3% of all those who owned a helmet, revealed that they either never wore their helmet, or wore it less than 50% of the time. Therefore, not only did less than

3% of all children report owning a helmet, but less than half of all helmet owners (46.7%) reported frequent use of their helmet.

In their survey assessment of bicycle helmet use among university students, Fullerton and Becker (1991) documented that 31% stated they owned a bicycle helmet. Of those who owned a helmet, 54.8% reported wearing their helmet over 75% of the time.

Evaluation of helmet use among avid or professional cyclists was solicited by the remaining researchers. Sgaglione and associates (1982) noted that 41.9% of all urban cyclists reported wearing bicycle helmets. However, nearly 75% of the bicyclists who incurred a head injury were not wearing a helmet at the time of the accident (Sgaglione et al. 1982). Similarly, 53.9% of the cyclists surveyed by Kiburz and colleagues (1986) stated that they routinely used a helmet. Although, only 32.7% were wearing helmets at the time of their accident. Interestingly, use of a bicycle helmet appeared to be the only piece of safety gear that did not correlate with years of riding experience. Gloves, toe clips, and mirrors were all positively associated with cycling experience (Kiburz et al. 1986).

Distinct from road cyclists, the vast majority of all terrain cyclists wore bicycle helmets. Chow and colleagues (1993) found that 86% of the all-terrain riders surveyed, stated they routinely wore bicycle helmets. Correspondingly, 88% of all those injured were wearing a helmet at the time of their accident (Chow et al. 1993). While an important factor in road cycling, regular and proper maintenance of the bicycle appeared to be a crucial factor in the prevention of injuries among all-terrain cyclists.

Helmet usage patterns among avid and competitive cyclists appeared no different than among the general population, prior to the 1986 USCF policy mandating SNELL or ANSI approved helmets to be worn by all racers. Prior to the ruling, approved helmets were worn by only 12% of all racers, with a 0.5% corresponding incidence of head injury. Following the ruling, 100% of cyclists wore approved helmets while racing, and no head injuries were documented during 1986. However, as evidence by the above survey responses, the complete compliance with mandatory helmet use under racing conditions, did not carry-over to training periods.

Substance Abuse

Substance abuse is not frequently associated with bicycle-related accidents, but it has been noted to contribute to a small percentage of these accidents. Chow and colleagues (1993) reported that 2.6% of the all-terrain cyclists they surveyed, revealed that they were under the influence of either alcohol or marijuana at the time of their accident.

Professional Involvement

Assessment of physician awareness concerning bicycling injuries and helmet use was the rationale for two studies conducted by Weiss and Duncan (1986) and Ruch-Ross and O'Connor (1993). Weiss and Duncan mailed a questionnaire to all pediatricians and family physicians listed in the telephone directory of Tucson, Arizona. A total of 106 of the 161 (65.8%) questionnaires were returned. Sixteen family physician respondents were excluded as they did not provide well-child care services, leaving 90 completed questionnaires for analysis. The percentage of physicians who accurately noted that bicycle fatalities exceeded fatalities from other childhood causes, are presented below. In parentheses following the selected causes of childhood fatality, are the percentages of physicians who accurately noted that bicycle fatalities surpassed that particular mechanism of childhood death: firearm injuries (92.5% answered correctly), falls (81.3%), meningitis (77.5%), and accidental poisoning (55%). Moreover, physicians were over-whelming aware (92%) that less than 5% of all children wore bicycle helmets (Weiss and Duncan 1990). Despite this, only 4.5% of the physicians reported that they "almost routinely or routinely" discussed bicycle safety with parents and children. Therefore, it was surprising that 78.9% of all physician respondents felt that parental unawareness of the importance of bicycle helmets, was the primary reason children did not wear them.

A few years later, Ruch-Ross and O'Connor (1993) published the results of an American Academy of Pediatrics survey. One thousand six hundred twenty-four members were randomly selected to complete a self-administered questionnaire concerning bicycle safety and helmet use. A total of 1201 physicians returned the questionnaire, for a response rate of 74%. Approximately 21% of the physician respondents indicated that they frequently rode a bicycle. But surprisingly, the majority of physicians (39.4%) reported that they never wear a helmet. Moreover, among physicians who have children aged 17 years or less, only 17% conveyed that their children always wore a helmet.

Among the 1201 physician respondents, bicycle safety counseling was performed by 871 (72.5%). Both helmet use and bicycle safety issues were discussed by 62% of physicians, while 14.4% revealed they discussed only helmet use, and 3.6% stated they discussed only bicycle safety issues (with no mention of helmet use) with their patients and parents. Of the 665 physicians who provided age-specific counseling information, 45.3% revealed that the age at which they began bicycle safety instruction was with patients aged 5-12 years. Similarly, 96.2% reported that they discussed bicycle safety issues with this same age group.

The potential lack of helmet use by physicians and their families may be related to the percentage of serious bicycle-related injuries treated by family physicians and pediatricians. Among this group of physician respondents, 21.3% reported having patients who sustained serious or fatal injuries due to a bicycle accident. Furthermore, it was surprising that any of these physicians (3%) documented that they had not heard of the efficacy of bicycle helmets. Because the preponderance of respondents stated that they were educated on bicycle helmet information from the American Academy of Pediatrics (79.7%) and through professional journals (65.3%), peer education appears to be the forum of choice for these professionals.

The above two studies suggest that up to 50% of all pediatricians and family practice physicians do not educate their patients, or their parents, on the use of bicycle helmets and other bicycle safety issues. This is an alarmingly high percentage, considering parents often view them as their advisors regarding childhood health issues, a concept that was documented by Eichelberger and colleagues (1990).

Summary

The characteristics of the population of bicyclists most likely to incur a bicycling accident remains unchanged from the previous two sections. Males and children less than

16 years are more likely to experience bicycling accidents, while bicycle-motor vehicle collisions, although less common, are more likely to result in bicycling fatalities (Waller et al. 1971; Sgaglione et al., 1982; Fullerton & Becker 1988; Chow et al., 1993). Accidents were most common during daylight hours, and during the summer months (Waller 1971; Sgaglione et al. 1982; Kiburz et al. 1986; Chow et al. 1993). Injuries characteristic of bicycling accidents are primarily orthopedic and/or neurologic in nature. Orthopedic injuries (extremity injuries) appear most common, as they are typical among cyclists with minor and moderate injuries, which comprise the majority of bicycle injuries (Sgaglione et al., 1982; Kiburz et al., 1986; McLennan et al. 1988; Chow et al., 1993). In contrast, neurologic (head injuries) injuries are reportedly more prevalent among cyclists with severe and fatal injuries (Sgaglione et al., 1982; Kiburz et al., 1986; McLennan et al. 1988; Wasserman et al. 1988; Fullerton & Becker 1991; Wasserman & Buccini 1991; Chow et al., 1993).

Review of observational and survey data provides information lacking from hospital and judiciary acquired data, namely, the people's perspective. Responses from cyclists, be they amateur, professional, or recreational cyclists, yields valuable information regarding bicycle safety and hazard patterns. Gratifyingly, the aforementioned bicycling injury characteristics were supported. More importantly however, information was gained on exposure (bicycling use, level of experience) and its relation to injury patterns.

The articles reviewed in this section emphasize the importance of cycling experience. Both experience and age appear to profile the severity of injuries sustained by all cyclists (Waller et al., 1971; McLennan et al. 1986; Kimmel & Nagel 1990; Runyan et al., 1991; Chow et al., 1993). Younger cyclists (< 16 years) may possess neither the cognitive ability nor the dexterity to anticipate and effectively handle themselves when riding on the road. Their lack of compliance with road traffic safety rules, as discovered in the study conducted by Kimmel and Nagel (1990), may partially be attributed to their reported unawareness of the rules. Thus, it is not surprising that younger cyclists are often cited as being responsible for their bicycling accidents.

Conversely, more mature avid cyclists (> 16 years) involved in bicycling accidents, are more prone to accept responsibility for their accidents whether or not the accident involved a collision with an automobile (Sgaglione et al. 1982; Kiburz et al. 1986; Chow et al., 1993). Nevertheless, motorists were more often implicated in adult bicycle accidents, compared to child bicycling accidents. The experience factor noted in the majority of studies reviewed, appears to extend to competitive cyclists as well. The more experience the professional cyclist possesses, the less likely he is to incur a bicycling accident in training or in a race (McLennan et al. 1988). Furthermore, environmental conditions, such as road debris and poor weather conditions, were more often cited as contributing factors in accidents incurred by more mature, urban cyclists.

It is not surprising that cycling injuries and fatalities among males outnumber those of females, often overwhelmingly. In all but one study reviewed in the section, did male cyclists outnumber female cyclists (DiGuiseppi et al. 1990). Moreover, not only were male cyclists more prevalent, they were also noted to amass more cycling mileage (Sgaglione et al. 1982; Kiburz et al. 1986). Thus, it was not surprising that males were noted to experience more cycling accidents. However, what was surprising was the finding that males were more prone to minor injuries, than females (Sgaglione et al. 1982; Kiburz et al. 1986; Fullerton and Becker 1991).

Another intriguing finding was the perception of the efficacy of bicycle helmets. Despite the fact that helmets have been shown to reduce the severity of brain injuries, all cyclists (amateurs, professionals, and recreational cyclists) do not believe their use is always essential. A large number of cyclists who own helmets, admittedly do not wear them on a consistent basis. Comfort and appearance issues, together with voluntary omission, are the leading causes of their lack of use (Sgaglione et al. 1982; Kiburz et al. 1988; McLennan et al. 1988; Wasserman et al. 1988; DiGuiseppi et al. 1990). In lieu of the following: 1.) All cyclists admit that they do not wear a helmet on a regular basis, 2.) The incidence of bicycle-related traffic fatalities have remained essentially unchanged since 1980, 3.) The incidence of head injuries resulting from bicycle-related accidents also appears to have remained fairly constant over the years, as evident by the rates and percentages reported by all researchers reviewed up to this point, and 4.) Various national and consumer reports have indicated a marked increase in the popularity of bicycling, there does not appear to be a substantial amount of evidence to support the need to embrace compulsory helmet legislation for all cyclists.

Race and socioeconomic issues pose a limitation to the generalizability of these findings. The majority of the studies reviewed were either conducted in predominately white, upper middle class communities (Waller 1981; Wasserman et al. 1988), or through bicycling organizations and magazines whose membership fees may exclude cyclists who cannot afford them (Kiburz et al. 1986; Wasserman and Buccini 1990; Chow et al. 1993). This is an important limitation, as previous research has shown that traumatic injuries by all mechanisms, were most prevalent among minorities. Additionally, the socioeconomic structure of the studies utilizing various sample populations, has frequently emerged as a potential contributing factor to overall injury rates. Indeed, a positive association has been reported between the effect of socioeconomic status and bicycling safety, namely helmet usage, among those studies reviewed which provided racial or socioeconomic information (Waller 1981; Wasserman et al. 1988; DiGuiseppi et al. 1990; Fullerton and Becker 1991). Particularly, the relationship between helmet usage patterns (both purchasing power and usage) and low income, knowledge level, financial ability, and race, cannot be overlooked.

However, as previously cautioned, because many of these studies involved the analysis of self-report or interview data, care must be taken to not over-interpret the findings as misinformation, misinterpretation, and observational and coding errors cannot be excluded. Additionally, inferences to the general population should be made with prudence, as severely and fatally injured cyclists, and those foregoing cycling for an alternative form of exercise, would not be included in the potential subject population of observational and survey studies performed roadside, or at the site of organized bicycling rides.

Programs/Campaigns Advocating Helmet Use

The use of observational or survey methods in the evaluation of bicycle helmet programs or campaigns promoting their use, are subject to the same limitations as all other observational and survey studies. Some sources of potential error include sampling error, measurement error, and response error (coding error, interviewer inconsistencies, and subject misunderstanding). Misinformation on the part of the respondent may also be an important factor. Children may supply answers they know their parents, teachers, or survey administrators want to hear. Parents may want to be perceived in a better light, or must rely on answers provided to them by their children. Accordingly, as previously cautioned, care must be taken before any inferences are made to the population at large. This is especially important, if the sample is not representative of the general population on decisive issues, for example, socioeconomic and racial distributions.

Observational and survey studies being critiqued in this section were reviewed according to two subdivisions, "Population specification, program overview and purpose," and "Effectiveness of program/campaign." Identical divisions as those in the above sections were not created, as the design of these studies is distinct from those previously reviewed. Age, gender, racial, socioeconomic considerations, time of day/week and seasonal variations, collision type, assignment of fault, and substance abuse were not principal factors in the these studies. Rather, their (age, gender, racial and socioeconomic data) documentation was primarily provided to supply information into community demographics. A change in helmet use was the quintessential component of all studies, with one exception. One study sought to evaluate the effect of bicycle lanes, and not a program to increase helmet use. This study will be reviewed last, due to its atypical objective.

Population Specification, Program Overview and Purpose

One of the leading injury prevention centers in America, the Harborview Injury Prevention and Research Center in Seattle, Washington, organized a team of professionals concerned about bicycle safety. They developed the Seattle Children's Bicycle Helmet Campaign, which layed the foundation for many programs to follow. Members of the Harborview Injury Prevention and Research Center in Seattle, Washington published a series of articles detailing the aspects and results of their campaign (DiGuiseppi, Rivara, Koepsell & Polissar 1989; Allen, Burg, Levine, Starfield, & Greenberg 1990; Rogers, Bergman and Rivara 1991; Rivara, Thompson, Thompson, Rogers, Alexander, Felix, and Bergman 1994). The goal of the campaign was to increase helmet use among Seattle's children. How to accomplish this goal, led to the organization of a multi-faceted coalition. The first three articles in this series detailed the multi-faceted components of the Seattle campaign. Members of the Seattle campaign elected to concentrate their efforts on attempting to alter the behavior of elementary school and middle school children, rather than junior high and high school children This decision was made because the researchers felt behavior modification of older children was beyond their capabilities, in spite of the data indicating that older children were at greatest risk of sustaining serious bicycle-related head injuries (DiGuiseppi et al. 1989; Bergman et al. 1990; Rogers et al. 1991).

Based on the results of an attitude survey of third grade children and their parents, the Seattle Children's Bicycle Helmet Campaign identified three fundamental issues they aimed to conquer: 1.) increasing parental and community awareness, 2.) making bicycle helmets more affordable, and 3.) encouraging youth to wear helmets. The first goal, increasing parental and community awareness, addressed the protective effects of bicycle helmets by uniting the media (television, radio and newspaper), health care personnel (physicians and nurses), bicycle trauma victims, and professional sports figures, to raise public awareness (DiGuiseppi et al. 1989; DiGuiseppi et al. 1990; Bergman et al. 1990; Rogers et al. 1991). The publication and distribution of various types of educational information, including promotional pamphlets, posters, human-interest stories, and feature stories formed the basis of this stratagem.

The second plan, making bicycle helmets more affordable, was to enable helmets to be purchased for less than $25.00. The inability of a bicycle helmet company to profitably mass produce a safe bicycle helmet in this price range, led to the proposal of discount coupons for youth bicycle helmet purchases. This proposal enabled a trademarked children's helmet for youth aged 5 to 18 years, and its counterpart helmet for children aged 1 to 5 years, to be purchased for $25.00 from a popular retailer of bicycle helmets. The last tactic of the Seattle campaign, encouraging youth to wear helmets, involved the recruitment of professional and collegiate sports figures, endorsement by area bicycling clubs, and the organization of bicycle rodeos. Coupons for fast food, tickets to sports games, and other prizes were also distributed to children observed wearing helmets.

The first in this series of articles published by the Seattle injury prevention center, was a study published by DiGuiseppi and associates (1989). The authors aimed to evaluate the early effects of this campaign, by comparing Seattle children exposed to their program, to Portland, Oregon children who were reportedly exposed to no program. Using a formal sampling method, DiGuiseppi and associates (1989) obtained the 1980 U.S. census tract information for both Seattle and Portland. The census tracts were first ranked by median income, then divided into three tertiles of children aged 5-14 years who were identified as being a member of a low income, middle-income, or high-income family (DiGuiseppi et al. 1989). Because the cost of living index in 1988 was higher in Seattle (106.7) than in Portland (104.1), the median household incomes used to define the three tertiary levels were also different. The median household incomes forming Seattle's three socioeconomic levels were \$16,989 or less, \$16,990 - \$21,609, and \$21,610 or higher, respectively. In comparison, Portland's three socioeconomic levels were delineated according to the following median household incomes, \$14,336 or less, \$14,337 - \$17,196, and \$17,197 and above, respectively.

A preliminary survey of Seattle children, a non-published study by Rivara and Bergman 1986, found that approximately 2% of all children who owned a bicycle wore a helmet. Therefore, an effect size from 2% to 6% was used to calculate the needed sample size within each income level. One hundred and fifty observation sites were allocated to each city, and among each of the three census tracts according to the estimated probability of children residing in each census tract. The same sites were reportedly used for the four observation periods starting May 1987 and spanning through September 1988 (DiGuiseppi et al. 1989). The selected sites in Seattle and Portland were respectively comprised of 20% and 24% schools, 28% and 17% parks and playgrounds, 11% and 3% bicycle paths, and 40% and 56% street intersections. The authors report that the discrepancies between the two cities, reflected the availability of the various sites in each of the two cities. However, these proportional disparities together with a failure to comply with a major condition of the stratification approach used, may have confounded the results. These considerations will be addressed in the proceeding subdivision of this section.

A follow-up study of the previously identified Seattle sites was performed in 1992 (Rivara et al. 1994). Rivara and associates (1994) re-evaluated the selected sites for helmet compliance and the incidence of bicycle-related head injuries. However, the confounder score devised for the previous study was not applied to the findings of this study. The authors report that application of the confounder score to the data was not crucial as unadjusted and adjusted rates were nearly identical (Rivara et al. 1994). This decision raises questions about its appropriateness in the earlier study.

In contrast to the extensive campaign implemented in Seattle, Washington, Weiss (1992) sought to determine if attitudes toward bicycle helmets changed over the course of five years, without any direct educational or safety campaigns purporting their use. Children and young adults in Tucson, Arizona from 4 elementary schools, 3 middle schools, 3 high schools and one university campus constituted the subject population. The selection of schools were reportedly based on their proximity to the University of Arizona

College of Medicine. Observers positioned in direct view of each school's bicycle racks, used for temporary storage of the bicycles during class-time, recorded all cyclists with and without helmets (Weiss 1992). The exception to this approach was at the university campus, where the observer recorded the number of cyclists entering the campus during one hour through a single campus entrance. All observations were reportedly made on sunny, autumn days, with temperatures ranging from 60° to 80°F. Both the 1985 and the 1990 observational phases of the study were conducted at the same schools, using identical methodology, and under the same seasonal and weather conditions. Observers documented 108 elementary school cyclists, 103 middle school cyclists, 107 high school cyclists and 150 university cyclists.

Pendergrast and associates (1992) advanced Weiss's study (1992) to the next level, by comparing the effectiveness of non-direct, mass media information, with a comprehensive school-based safety program. Two elementary schools in Augusta, Georgia participated in the study. Both schools reportedly had similar socioeconomic and ethnic distributions, and were chosen from two separate school districts to prevent cross-contamination of information (Pendergrast et al. 1992). The parents and children in grades 2, 3, and 4 at both schools received a pretest in May 1990. Each pretest was accompanied by general and bicycle-specific safety information, helmet use, and a copy of the "SAFE KIDS" magazine for children, and the corresponding "child safety magazine" for adults. Upon return to school in September 1990, all children and their parents (then in grades 3, 4, 5), received another reminder letter about bicycle safety, a pamphlet describing the correct manner to ensure proper helmet size, additional information from the "SAFE KIDS" campaign, and a $10.00 bicycle helmet subsidy coupon. All coupons expired December 1990, and were specially coded to allow for future tracking. The post-test consisted of a third reminder letter and at least one of the educational pamphlets previously provided during the pre-test phase.

In addition to the above material, Pendergrast and associates (1992) had hoped to create a more comprehensive program for the children attending the "case school." Following several meetings with the school's PTA, the creation of a "school bike club" with posters, stickers, and planned bicycle events organized in cooperation with a local bicycle retailer emerged. However, lack of parental support and practicality for this campaign led to its demise (Pendergrast et al. 1992). The alternate plan for the children attending the "case" school, and their parents, involved a demonstration from a professional stunt rider who illustrated the importance afforded by bicycle helmets.

Pre-test characteristics included 209 of 287 (72.8%) children (43.7% female) and 125 of 287 (43.5%) adults (82.3% female) for the case school. In comparison, 470 (89.2%) of the 527 children (50% female) and 364 (69.1%) of the 527 adults (78% female) for the control school. Post-test characteristics varied slightly with 184 of 302 (60.9%) children (47.3% female) and 132 of 302 (43.7%) adults (85.5% female) for the case school, compared to 391 of 565 (69.2%)children (51.7% female) and 336 of 565 (59.5%) adults (81.2% female) for the control school. Accordingly, although the majority of parent respondents were females, the distribution of children was approximately equal. Parents and children differed on their views of themselves and their respective counter-parts as bicycle riders. Pre to post-test changes related to this topic revealed that adult respondents identified 92% of children and 37% of adults as bicycle riders at pre-test, versus 87% of children and 31% of adults at post-test. Conversely, children identified themselves as bicycle riders on the pre and post-test at 95% and 96%, respectively.

Assimilating the strategies of the Seattle Children's Bicycle Helmet Campaign with those of Pendergrast and associates (1992), Puczynski and Marshall (1992) aimed to evaluate the effectiveness of a regional mass media bicycle campaign and subsequent educational program. Similar to the Seattle campaign, Puczynski and Marshall (1992) solicited the assistance of regional professional athletes, the board of education, members of the hospital staff, and bicycle dealers. The first phase of the campaign consisted mainly of public and media advertisements and interviews via radio and television, along with the simultaneous distribution of printed material including pamphlets and posters. However, unique to this study, was the second phase which aimed to increase public awareness through the publication and distribution of a "bicycle helmet guide," and acquisition of privately donated billboards which displayed the campaign's slogan, "Helmets! All the Pros Wear Them." In addition, implementation of a safety educational program in one of two elementary schools, similar in size and major demographic characteristics, formed the final component of phase two. All children in grades 1 through 5 in the designated case school received a free bicycle helmet following 4 weeks of safety instruction. The curriculum was developed by the Bicycle Federation of America, and was taught by physical education teachers at both of the schools (Puczynski and Marshall 1992). A total of 8 hours of instruction was provided. Conversely, children in the control school reportedly received no additional instruction beyond the community awareness program comprising phase one of the study, nor did the children receive free helmets.

Analogous to earlier studies, Liller and associates also implemented a community and school bicycle helmet campaign. However, pre-school children rather than elementary school children were the focus of this school study (Liller, Kent, Knowles, and McDermott 1995). Liller and associates study was implemented in Florida, where the proportion of children fatally injured from bicycle-motor vehicle traffic accidents was more than twice the national average at the time (Liller et al. 1995). A preliminary observational study was conducted by the authors to assess the prevalence of helmet use among elementary school children. The observational study was reportedly based on the guidelines proposed by DiGuiseppi and associates (1989), which are noted above. All observational periods occurred during the day. The preponderance of observed subjects were male (59.4%) and white (86.7%), which reflected the distribution in the upper-middle class community where the observations were made. Racial disparities in helmet use were noted. Of the 86.7% white children, 7.3% were observed wearing a helmet. In comparison, none of the black children, who comprised 7% of the total sample, were observed wearing a helmet.

The results of this preliminary observational study reportedly led to the design of a community-wide helmet campaign. The purpose of the program was to increase awareness of health professionals, educators, parents and children about the protective effects of bicycle helmets. The program included bombarding members of the community with educational material, such as brochures and posters, while joining efforts with a local toy store to provide discount helmet coupons, and a free bicycle accessory with the purchase of every child's helmet during a two month period (Liller et al. 1995). Educational literature was made available in hospitals, walk-in clinics, at various youth organizations and fairs, as well as at municipal recreational areas, museums, law enforcement offices, and insurance agencies. In addition, an area preschool caring for children aged 2-6 years from all socioeconomic levels, was selected for the implementation of a comprehensive educational program (Liller et al. 1995). Various national educational campaigns provided age-appropriate literature to be distributed to parents or posted in the school. Age-appropriate activities, such as "making paper helmets," and police attended bicycle and tricycle races and obstacle courses, were implemented. All activities sought to increase awareness of traffic signs and rules, and the importance of bicycle helmets.

A less direct approach was attempted by Schneider and colleagues (1993), who implemented a community-wide coalition to promote the use of bicycle helmets. The campaign consisted of television and radio public service announcements, direct mail and telephone communication detailing information intended to "increase parental worry about bicycle accidents and parental belief that helmets are an effective means of reducing risk of head injury," and a local bicycle rodeo where helmet subsidy coupons were distributed (Schneider et al., p. 283).

Schneider and colleagues (1993) performed a random telephone survey pre and 6 months post the community bicycle safety campaign (Schneider, Ituarte & Stokols 1993). The pre-campaign survey was performed to identify children who did not currently own a helmet. A total of 595 parents having children between the ages of 5 and 18 participated in the pre-campaign survey, for a response rate of 45%. In comparison, the post-campaign survey consisted of 210 of the 412 parents identified from the pre-campaign whose children did not own bicycle helmets, for a response rate of 51%. Characteristics of respondents of the pre-campaign survey varied little from those of the post-campaign respondents. The mean age of both respondents was 39 years, with a greater percentage of female respondents (67% pre-campaign, and 76% post-campaign). Racial disparities remained relatively constant for both surveys (whites comprising 83% and 84% of the respondents, and nonwhites the remaining 17% and 16%, respectively). Similarly, less than 10% of the respondents (8% pre-campaign and 7% post-campaign) had incomes less than $25,000 per year, in comparison, greater than 50% of the respondents (59% pre-campaign and 64% post-campaign) reported a household income greater than $50,000 per year. The remainder of the respondents reported incomes in the range of $25-50,000 (Schneider et al. 1993). The level of education of all respondents also remained fairly constant across both survey periods, as evident by the following distribution: 11% of survey respondents both pre and post-campaign had a high school education or less, 26% and 30% of the respective respondents had some college education, 38% and 35% of the respective respondents were college graduates, while 25% and 24% of the respective respondents had post graduate education.

Evaluation of three Maryland counties' bicycle helmet use, served as the aim of two articles published by members of the Injury Prevention Center at John Hopkins University, in Baltimore, Maryland. The first of these studies aimed to evaluate the effect of legislation and education on helmet use through an observational study (Cote' et al. 1992). The important distinction between each of the three communities, was the extent of the education and/or legislative campaign in place in each community. Montgomery County initiated the most comprehensive educational campaign in May, 1990 (Cote' et al. 1992). Their bicycle helmet program utilized television, radio and newspaper advertisements, the distribution of miscellaneous literature, including flyers, pamphlets and posters, the rendering of education material to teachers and school nurses, and the distribution of 10,000 bicycle helmet subsidy coupons during community fairs (Dannenberg et al. 1993). In addition, Montgomery County passed a bicycle helmet law similar to the one passed in Howard County in July, 1990. This law, passed on June 4, 1991, mandated that all children 16 years and younger wear a bicycle helmet when riding on county roads or paths. In comparison to Montgomery County, Howard County 's bicycle safety program was less comprehensive. Their program included the distribution of educational material to teachers with an increased emphasis on bicycle safety in health education classes, the incorporation of a bicycle helmet curriculum into some physical education courses, and the creation of bicycle rodeos at some middle schools. Most important, however, was the passage of a county law on May 7, 1990 requiring all bicyclists to wear a helmet. This law was subsequently modified on July 30, 1990 to include only those children less than 16 years of age. The media promotion of the latter 1990 law, requiring all children under the age of 16 years to wear an approved bicycle helmet when riding on county roads or paths, became the primary focus of the Howard County campaign (Cote' et al. 1992; Dannenberg et al. 1993). The third county surveyed was Baltimore County, excluding Baltimore city. No active bicycle safety education or media programs were being implemented, nor were any legislative efforts in effect (Cote' et al. 1992; Dannenberg et al. 1993).

Volunteer observers solicited from the community were sent training material 1-week prior to the study, and were required to attend a 1-hour training session the day of the study (Cote' et al. 1992). Observations were conducted at 4 sites associated with each of ten pre-determined routes per county. The chosen socioeconomic strata were comprised of 20 middle class and 20 upper-middle class communities, as identified by the U.S. census tracts. Within each community, an equal proportion of observational sites were selected from among various locations near schools, recreational centers or pools, county thoroughfares, residential streets and parks or bicycle paths (Cote' et al. 1992). Pairs of observers worked a selected site for approximately 45 minutes. Observers estimated the age, gender, race, and helmet use for a sample of the bicyclists observed. Bicyclists were classified as "child" if perceived to be less than 13 years old, "teen" if thought to be between 13 and 19 years, and "adult" if felt to be 20 years of age or older. Discordant perceptions were reportedly handled in a uniform manner. Concern over potential prior public awareness of the study's implementation led investigators to include a simultaneous interview of a sample of the observed cyclists to inquire about their prior knowledge of the conductance of the study. Observations were performed on two separate occasions. The initial baseline observation period took place on Saturday, July 28, 1990. The second, or follow-up, observation period occurred on Saturday, May 4, 1991.

A total of 246 bicyclists perceived to be less that 16 years of age were observed at baseline. Observer agreement reportedly differed by no more than 4% for gender, 2% for race, and 1% for helmet use. Among the bicyclists observed in Howard County, the total sample was predominately male (83%), white (84%), and upper-middle class (68%). Similarly, the composition of Montgomery County bicyclists was also predominately male (84%), white (81%), and from an upper-middle class community (75%). Although the observed Baltimore County bicyclists were also primarily male (65%), white (97%) and residents of an upper-middle class community (76%), more females, less minorities and more cyclists in upper-middle class communities were observed. A disproportionally lower percentage of bicyclists were observed at schools, recreational centers or pools in Howard (7%) and Baltimore (8%) counties, when compared with all other observational locations within each county, and with similar Montgomery County bicyclists (36%). The largest percentage of all children in both Howard and Montgomery counties were observed riding with other children less than 16 years of age, 43% and 51% respectively.
While the greatest proportion of Baltimore County bicyclists under 16 years, were observed riding with non-helmeted bicyclists 16 years or older.

In comparison to the baseline findings, a total of 202 bicyclists discerned to be less than 16 years of age were observed at follow-up. Agreement between the pairs of observers reportedly did not differ by more than 6% for gender, 2% for race and 7% for helmet use (Cote' et al. 1992). Subject characteristics varied slightly from baseline, however, the samples from each of the three counties remained primarily male, white, and were observed most frequently riding in upper-middle class areas. Specifically, the percentage of male cyclists decreased in both Howard and Montgomery counties to 77% and 70% respectively, while increasing in Baltimore County from 65% to 78%. Similarly, the proportion of white cyclists also increased in both Howard (84% to 94%) and Montgomery (81% to 86%) counties, but decreased in Baltimore County (97% to 90%). Bicyclists were least likely to be observed riding in residential areas in both Howard (6%) and Montgomery (12%) counties, in contrast to baseline where school/recreational/pool areas were least common. Schools/recreational/pool areas and parks or bicycle paths remained the most common cycling location for children less than 16 years of age to ride their bicycles in Montgomery County, accounting for 32% and 39% of all observed children. Lastly, children under the age of 16 years riding together with other children less than 16 years remained the primary cohort of youth cyclists.

The latter publication involving the same Maryland county communities, not only sought to evaluate the three counties with respect to their progressively more intense bicycle helmet programs in 1991, but was also interested in gaining insight into children's perception of the importance of bicycle helmets and their self-reported use of helmets (Dannenberg et al. 1993). A total of 47 schools were randomly selected to participate in the survey following stratification by geographical location. Students in grades 4, 7, and

9 were surveyed, thereby coinciding with the inclusion of elementary schools, middle schools and high schools. Surveys were mailed to parents with a cover letter requesting that their child complete the survey without any parental assistance. A pre-addressed stamped envelop was provided for return of the survey. Reminder postcards were mailed 10-20 days following the initial mailing (Dannenberg et al. 1993). A total of 2712 surveys were mailed to Baltimore County students in May 1991, 2278 surveys were mailed to Howard County students in June 1991, and 2332 surveys were mailed to Montgomery County students in October 1991. The response rate varied for each county. Baltimore County had a 47.7% response rate, Howard County a 51.2% response rate, and Montgomery County a 46.5% response rate. The overall response rate for all counties was 48.4%. Grade-specific response rates for each of the counties ranged from 41% to 52%. Gender-specific response rates for each of the counties from 44% to 50% for boys and 47% to 52% for girls.

More recently, Macknin and Medendorp (1994) sought to evaluate the relationship between bicycle helmets, bicycle safety education and bicycle helmet legislation through a teacher administered questionnaire. Four upper-middle class, primarily white communities (87.2% to 95.7% white) in Cleveland, Ohio were selected. Correspondingly, the majority of all parents in each of the communities held a high school degree, or completed some college, ranging from 10.6% to 20.6%. Similar to the various communities in the study conducted by Dannenberg and associates (1993), progressively more intense programs were in practice in the communities selected by Macknin and

Mendendorp (1994). Two communities reportedly had no active bicycle helmet campaigns (Moreland Hills and Pepper Pike), one community instituted legislation in 1991 mandating all children under the age of 16 years to wear an approved bicycle helmet when riding bicycles off residential grounds (Orange), and 1 community not only had a similar legislation, but a bicycle safety educational program (Beachwood). The Beachwood community, through the aggressive efforts of an area pediatrician, instituted the bicycle helmet legislation in 1990. The helmet legislation gave police the authority to cite the parents of non-compliant youths with a $25.00 fine. However, reportedly, first offenders were often given an oral warning, with a written warning issued to their parents (Macknin & Medendorp 1994). This same school district also had a comprehensive educational program inclusive of school assemblies, where videos and slide presentations were shown, and provided information and bicycle helmet subsidy coupons to parents. In addition, Beachwood's PTA was also actively involved in the bicycle helmet campaign. The PTA rewarded bicyclists observed wearing helmets with coupons for free fast food at an area fast food chain, as well as promoted the use of helmets by selling them at the PTA sponsored bicycle rodeo. Moreover, the regional U.S. congressman for this area addressed the importance of helmet use in a letter which later became the focus of the area media reports on helmet promotion.

The observational phase of this study took place on residential streets, school grounds, main roads and municipal recreational grounds in Beachwood. However, the authors report that because the remaining participating communities did not have bicycle paths or sidewalks, only scattered numbers of children were observed riding their bicycles (Macknin and Medendorp 1994). Because of this, the authors chose to not complete the observational phase of the study in any of the remaining communities. Considering other researchers were able to adequately observe bicyclists in other communities with similar structural road conditions, it is difficult to understand why it could not be accomplished here (Wasserman et al. 1988; DiGuiseppi et al. 1989; Rivara et al. 1994; Liller et al. 1995; Rouzier & Alto 1995).

Overall, 1539 students in grades 1 through 7, participated in the survey. The majority of students were from Beachwood 640/1539 (41.6%). In comparison, 283/1539 (18.4%) were from Orange, 239/1539 (15.5%) were from Moreland Hills, and 377/1539 (24.5%) were from Pepper Pike. Males comprised 52% of the total population, with students in grade 4 forming the median grade level.

Researchers in Grand Junction, Colorado designed a multifaceted bicycle helmet campaign, which appeared to incorporate successful components of the previously mentioned campaigns. Creatively, Rouzier and Alto (1995) planned a two-phase bicycle helmet campaign, which included an educational and observational component, for the Grand Junction community, a community of approximately 76,000. The initial phase of the program consisted of a bicycle helmet campaign that was separated into two segments. The first phase of the helmet program began in 1992 and targeted 8600 elementary school children and their families (Rouzier and Alto 1995). These researchers rallied the support of an area hospital, health maintenance organization, local physicians, service groups, and concerned community members, to acquire contributions that were used to purchase wholesale bicycle helmets. These helmets were then sold to children for $5.00 and $15.00, based on their families reported income level, and to family members for $17.00. Low income families were asked to pay $5.00 for each helmet, while middle and upper-middle families were asked to pay $15.00 for each helmet. The honor system of reporting income level was used. Approximately 2400 bicycle helmets were sold during the 1992-1993 school year, among which 45% were redeemed for $5.00, 45% for $15.00, and 10% for $17.00. Each coupon used to purchase the helmet at the reduced fee, was imprinted with basic, but important reasons, reminding parents of the importance of donning a bicycle helmet.

Phase two of Rouzier and Alto's (1995) helmet campaign involved a local sporting goods store committed to the distribution of bicycle helmets to children at a reduced cost. In 1993, the store sold bicycle helmets for $12.99 to all school children, and later expanded its generosity to the general public. The philanthropic nature of the owner(s) of the sporting goods store, no longer made it necessary to continue to seek contributions from community members, organizations, and businesses. A total of 4000 bicycle helmets were sold over a one year period beginning September 1993.

In conjunction with the helmet portions of the Grand Junction bicycle helmet campaign, Rouzier and Alto (1995) secured the participation of 23 community elementary schools. Each school's physical education department incorporated a bicycle helmet program, devised by the Denver-based Headstrong organization, into its curriculum. In addition, media (newspapers, television promotions, poster advertisements), judicial (area traffic safety council and police), and health care personnel involvement was sought from the community. Police involvement utilized positive reinforcement tactics, such as rewarding children observed wearing a bicycle helmet while cycling, with discount coupons to fast food stores. Pre and post intervention observational periods were also scheduled to assess the effect of all campaign components: phase 1 and 2 helmet components, the educational component, and the police reward component. Observations were conducted by a medical student at 23 locations throughout Grand Junction, Colorado. Each observational period lasted 20 minutes, enabling the student to recall cyclists so that no cyclist was counted more than once. The 23 locations remained constant over the 3 year study period, but the time of day of observation varied.

Effectiveness of Program/Campaign

Researchers at the Harborview Injury Prevention Research Center in Seattle, Washington formulated a multi-faceted bicycle safety campaign, that targeted helmet use among children aged 5-15 years. The two primary outcome criteria used to evaluate the effectiveness of the Seattle helmet campaign were redemption of bicycle helmet discount coupons and observed helmet usage rates. The overall success of the discount coupon program was perceived to be extraordinary (Rogers et al. 1991). Reportedly, approximately 109, 450 discount helmet coupons were distributed in 1988, of which 4,155 were redeemed, for a redemption rate of approximately 4.7% (Bergman et al. 1990; Rogers et al. 1991). Helmet redemption rates increased to 10.6% in 1989, then slightly declined to 9.4% in 1990

(Rogers et al. 1991). Interestingly, additional helmet redemption rates were not provided in future publications updating the progress of the helmet coalition. Whether or not helmet redemption rates are the best estimators of helmet usage is questionable, as previous research has demonstrated that helmet ownership does not guarantee helmet use (Liller et al. 1995; Dannenberg et al. 1993; Schneider et al 1993; Cote et al. 1992; Puczynski and Marshall 1992; Fullerton and Becker 1991; DiGuiseppi et al. 1990; Kimmel and Nagel 1990; Wasserman et al. 1988; Kiburz et al. 1986; Sgaglione et al. 1986). The second outcome measure, observed helmet usage rates, was evaluated biannually among Seattle children following the implementation of the Seattle community helmet campaign. A nonrandomized observational intervention/control study was designed to evaluate the campaign's effectiveness. Members of the Seattle helmet coalition conducted an observational study comparing helmet use among Seattle and Portland children (DiGuiseppi et al. 1989). Portland children served as the control population. Crude proportions of helmet use among Seattle children reportedly increased from 5.5% in May, 1987 to 15.7% in September, 1988. Corresponding increases in helmet use among Portland children, reportedly increased from 1.0% in May, 1987 to 2.9% in September, 1988. However, Rogers and associates (1991) later reported that the higher baseline helmet rate in Seattle (5.5%), as compared to Portland (1.0%), was likely attributable to a helmet survey conducted earlier in the Seattle area.

Pre-exposure to the strategies included in the Seattle helmet coalition, may not be the only factor that possibly influenced the results reported by DiGuiseppi and associates

(1989). The appropriateness of the multivariate confounder score proposed by Miettinen (1976), and used by DiGuiseppi and associates (1989) with the calculation of the reported data from the Seattle/Portland study raises several questions. Miettinen (1976) notes that, "One sufficient condition for such poolability is that the strata in question have identical proportions of cases among the nonexposed" (p. 610). This condition would require that the Portland control population and the Seattle case population have similar proportions of helmeted cyclists among those subjects not exposed to any type of bicycle helmet campaign in either city. It does not appear that this criteria was met. One of the first studies published by members of the Harborview Injury Prevention and Research Center in Seattle, Washington was a case-control study that sought to evaluate the efficacy of bicycle helmets in the prevention of serious head injuries (Thompson et al. 1989). As previously described in the section labeled, hospital-based studies, the design of this study included a case population of bicyclists who sustained head injuries, and two control populations. The first control group consisted of cyclists who incurred injuries other than head injuries, while the second was comprised of members of a health maintenance organization who had sought treatment for bicycle-related injuries. Although the original study published by Thompson and associates (1989) included subjects of all ages, the authors did report helmet use by age, for both the case and control populations. Reportedly, helmet use in children less than 15 years of age was 2.1% among case (head injured cyclists) patients. In comparison, 5.9% of children less than 15 years of age in the first control group (non-head injured bicyclists), and 21.1% of similarly aged patients in the second control group, were registered as wearing helmets at the time of the accident, for which they sought treatment for their injuries.

However, DiGuiseppi et al. (1989) reported that only 2.1% of all observed Portland children wore helmets; the same proportion as among brain injured Seattle children not exposed to the community-wide helmet campaign. Notably, 2.1% of Portland control children is substantially less than the 21.1% of Seattle population control children reportedly wearing helmets prior to exposure to the Seattle Bicycle Helmet Coalition. This disparity of initial helmet use by the two geographic locations was acknowledged as a limitation by the authors. Thus, it is not surprising that the confounder score devised for the Seattle/Portland study did not appear beneficial in the follow-up study limited to Seattle sites.

An additional problem with the results published by DiGuiseppi and associates (1989) is the ambiguous application and resulting effects of the confounding score. The authors state that "race, bicycle type, site type, and whether the child rode alone or with adults and/or other children," were the variables comprising the confounding score (p. 2258). Unadjusted population characteristics reveal that the population of Seattle possessed a greater proportion of nonwhites (18.7%), a greater percentage of the population that was ≥ 25 years of age with a high school degree (81.3%), a lower unemployment rate (5.7%) and a lower percentage of children living in poverty (12.4%). In comparison, Portland presented with the following respective proportions 13.5% (non-whites), 75.8% (≥ 25 years with a high school degree), 6.9% (unemployment rate) and 17.0% (children living in poverty). Therefore, while the confounder score adjusted helmet use rates may have resulted in overall lower observed rates in Seattle children and higher observed rates in Portland children, consideration was not given to the higher mean income, lower unemployment rate, and lower percentage of children living in poverty among Seattle children. Although these factors may be partially balanced by the examination of each cities' observations by medium income census tracts, it does not counterbalance their effect. The authors defended their rationale by stating that relative comparisons between the two cities were appropriate as comparisons were not made between the two cities, but rather as a change from baseline in each of the two cities. However, this logic can be challenged by the findings of other studies that reported that helmet usage was lowest among lower income or socioeconomic levels (Rivara et al. 1994; Puczynski and Marshall 1992; DiGuiseppi et al. 1990; Eichelberger et al. 1990; DiGuiseppi et al. 1989; Wasserman et al. 1988). This notion that can be related to the financial feasibility of helmets for lower income parents. Accordingly, the contention that the lower educational level, higher poverty status, and higher unemployment rate found in Portland, will not have an effect on the results of this study because the change in helmet usage rates among Portland children were compared to a Portland baseline and not to Seattle, may be controversial.

Finally, information was not provided on the effectiveness of the stratification by the confounder score in controlling for the individual confounders. More specifically, because the values associated with the confounding score were not provided by the authors, it is difficult to assess whether the differences in the various confounding factors (race, site type, bicycle type, presence of companions, and helmet use by companions) were random, and thus resulted in zero when averaged over the strata (DiGuiseppi et al. 1989; Miettinen 1976). Therefore, it is difficult to evaluate whether the confounding score adequately adjusted for the above distinctions between the two cities, along with the higher sampling of sites in Seattle, in areas where helmet usage rates were expected to be higher -- bicycle paths, and parks and playgrounds.

The overall impact of the Seattle Children's Bicycle Helmet Campaign was not expected to be reportable for several years, as Harborview researchers stated "Given the low number of precampaign bicycle-related deaths (approximately 12 per year in Washington State) and the low rate of helmet usage, many years will pass before a change in the death rate can be discerned as a result of the campaign" (Bergman et al. 1990, p. 730; and Rogers et al. 1991, p. 75). However, Rivara and associates (1994) were able to report a reduction in the incidence of bicycle-related injuries, with special attention given to head injuries, from pre-campaign (1987) to 1992 in Group Health Cooperative (GHC) member children. Reportedly, medically treated head injuries among 5-9 year old children decreased from 283/100,000 in 1987 to 94.6/100,000 in 1992, for a total percent reduction of 66.6%. Similarly, bicycle-related head injuries among children aged 10-14 years decreased from 188/100,000 in 1987 to 60.9/100,000, for a total percent reduction of 67.6%. In addition, injuries other than head injuries sustained by children were also noted to decrease (Rivara et al. 1994). Non-head injuries sustained by children aged 5-9 years while cycling, reportedly reduced from 388/100,000 in 1987 to 335/100,000 in 1992, for a total percent reduction of 13.7%. A corresponding reduction in non-head injuries among child cyclists aged 10-14 years was also documented from 621/100,000 in 1987 to 460/100,000 in 1992, for a total percent reduction of 25.9%. Therefore, an overall injury reduction among child cyclists from pre-campaign (1987) to approximately 5 years post program initiation, was 36.1% (671/100,000 to 429/100,000) among children aged 5-9 years, and 35.6% (809/100,000 to 521/100,000) among children aged 10-14 years. The overall percent decrease in head injuries for all children less than 15 years of age was recorded as 48.9% (32.1/100,000 to 16.4/100,000).

Rivara and associates (1994) contributed the above reductions in bicycle-related injuries to the increase in helmet use among Group Health Cooperative (GHC) children of Puget Sound. They noted that helmet use among GHC children less than 15 years of age increased from 4.3% in 1987 to 54% for 5-9 year old children and 37.7% among 10-14 year old children, in 1992. Observed helmet usage rates among children less than 15 years of age, reportedly soared to almost 60% in 1993. A direct comparison among age groups was not possible, as helmet use was not distinguished between 5-9 year old and 10-14 year old children in 1987. These statistics support the benefit of a community-wide coalition in the reduction of preventable bicycle-related injuries. Most importantly however, the Harborview researchers recognize that the distribution of helmet subsidy coupons were central to the coalition (Rivara et al. 1994).

Although the effectiveness of the Seattle helmet coalition appears to have positively influenced helmet use, thereby indirectly reducing the number of bicycle-related head injuries sustained by members of the GHC, limitations of their findings need to be addressed. Demographically, GHC members and the surrounding Seattle metropolitan population were reported to be similar in terms of the percentage of families earning greater than $30,000 annually (Thompson et al. 1989). However, Rivara and associates (1989) previously reported that GHC members, "were less likely to be in the lowest income group (14%) than the surrounding Seattle metropolitan area (23%)" (Rivara et al. 1990, pp. 990 and 993). Moreover, substantial differences in the degree of education achieved by GHC members in comparison to residents of metropolitan Seattle reportedly differed. Thompson and associates (1989) noted that 67% of GHC members attained an educational level beyond a high school degree, versus only 47% of those in the Seattle metropolitan area. The incongruence widened with post-high school education. Rivara and associates (1989) noted that nearly one-half of the GHC member families' principal household member had a college education, in comparison to 23% of families comprising the surrounding Seattle metropolitan area. This discriminating factor was acknowledged by Harborview researchers, together with the disparate racial distribution. Thompson and colleagues (1990) revealed that the GHC population, "differs from the U.S. population by its greater educational level and underrepresentation of Blacks" (p. 1388). The ethnic distribution of GHC members included 91% Whites, 4% Asian, 3% Blacks, and 2% other (Thompson et al. 1989). In comparison, the corresponding ethnic composition of the United States was 83.4% Whites, 1.7% Asian, 11.7% Blacks, and 3.2% other (Thompson et al. 1989).

Because race (whites), educational attainment, and income level have all been noted to be positively associated with bicycle safety awareness, estimates of helmet use among GHC members would be expected to be higher than among other geographical regions, such as Portland. Thus, the choice of Seattle as the pilot city may have artificially inflated the potential success of similar community-wide campaigns in cities with socioeconomic, racial and educational levels, more closely resembling that of the United States as a whole. The above findings appear to support these conclusions, as does the efficacy assessment of the Seattle Children's Bicycle Helmet Campaign after 5 years of implementation. The rate of helmet use among Seattle children less than 15 years of age notably increased from 5.5% in 1987 to 40.2% in 1992 (Rivara et al. 1994). The proportion of girls donning helmets outnumbered boys, 47.2% to 38.1%. Children cycling on bicycle paths were more likely to wear helmets (82.7%) than children riding on streets (23.1%). Helmet use by children accompanied by parents using bicycle helmets, substantially exceeded helmet use among children riding with unhelmeted peers, 94.7% to 7% (Rivara et al. 1994). All of these factors -- gender, site type, and helmet use by companions, especially parents, have been previously associated with helmet use. Detection of the importance of these factors among Seattle children, however, also emphasizes the potential influence disparate proportions these factors may have had on the results noted between Portland and Seattle children. Lastly, but possibly most importantly, the observed bicycle helmet use among Seattle children reflected the ever prevalent socioeconomic discrepancy between white and blacks, and middle and upper income families, versus low income families. Helmet use observed among white Seattle children was 47.8%, versus 8.2% among blacks. Similarly, helmet use among Seattle children belonging to families with a low, medium and high household income were 31.6%, 41.7%, and 44.4%, respectively.

Recognition of these socioeconomic and racial disparities in a community that is primarily white and middle class, and among a community-wide coalition that prided itself on the organization of a bicycle helmet campaign whose effects "reached children from all socioeconomic groups" is troublesome (DiGuiseppi et al. 1989, p. 2260). An editorial by H. Jack Geiger, MD (1996) in the New England Journal of Medicine examined the influence race and economic status has on the health care system in the United States. He reminded us that evidence exists depicting the disparities between black and white patients, and disadvantaged and affluent patients. Whatever the reason for these discrepancies, we as educators and health care providers must find a way to reduce the health care inequalities experienced by disadvantaged and black community members.

Weiss's (1992) evaluation of non-specific awareness, or merely general momentary advertisements in the lay press, in changing the helmet use patterns among school-age through university students was mixed. Helmet use among middle school remained unchanged from 1985-1990; no students were observed wearing helmets either time. Similarly, only 2 high school students were noticed wearing helmets in 1985 (1.86%), while only 1 was noticed wearing a helmet in 1990 (1.45%). The down-ward trend in helmet use continued for university students as well. Fifteen of the 150 (10%) university students were observed wearing a bicycle helmet in 1985, in comparison only 10 of 225 (4.4%) students were wearing helmets in 1990.

Examination of the change in helmet use patterns among school-age children was confounded by the implementation of an annual bicycle safety program in one of the three elementary schools. This program consisted of classroom instruction, followed by an outdoor bicycle rodeo. Helmet use among the students of this school was noted to increase from 4.4% in 1985 to 21.4% in 1990 (Weiss 1992). Although not as great, the helmet use among the other three elementary schools was also found to increase from 0% in 1985 to 13.8% in 1990 ($p = 0.011$). Thus, in contrast to older children and young adults, the dissemination of non-direct bicycle safety information does appear to occur. Speculation may suggest an increase in bicycle safety awareness and parental authority among the parents of school-age children. Conversely, lack of influence over older children as they explore the various paths along their road to adulthood, may contribute to the lower percentage of helmet use among these students.

Pendergrast and associates' (1992) evaluation of an indirect, mass media and comprehensive school-based safety program in Augusta, Georgia, showed an increase in the number of adults and children who reported ever using a helmet, as evident by pre to post test findings. The percentage of adults ever using a helmet increased from 5.6% to 20.5 % in the case school, versus 5.5% to 10.3% in the control school. Similarly, the percentage of children ever using a helmet increased from 4.5% to 16.5% in the case school, in comparison to 7.7% to 11.3% in control school. No significant difference was noted between the case and control adults and children. Not only was no significant difference noted in response to the above questions, but the percentage of children who wore helmets during their last ride decreased for case children from pre to post-test (7.4% to 4.4%, respectively). In contrast, the percentage of control children who reported that they wore a helmet during their last ride increased slightly from 6.5% to 7.2%.

Case children were significantly more likely to respond affirmatively to the following questions at post-test: 1.) "A helmet helps protect you, " and 2.) "Wearing a helmet is a good idea," it did not statistically alter the percentage of children who reported that they intended to wear a helmet during their next ride. Despite this finding, the percentage of children who reported they would wear a helmet during their next ride increased only slightly for case children from 14.6% to 15.2%, and decreased slightly for control children from 15.8% to 13.6%. Comparably, no significant difference was noted between the two schools. The children cited "forgetting" (23%), discomfort (21%), and "concern about appearance (12%) most frequently for not wearing a helmet. The failure of this approach to increase the use of bicycle helmets was substantiated by the record that only 4 subsidy coupons were redeemed. Finally, Pendergrast and associates (1992) reported that socioeconomic considerations did not alter the outcome. However, no data was provided to support this claim.

Regression analysis by Pendergrast and associates (1992) revealed that parental helmet use, social perceptions of helmet use, and personal attitudes towards helmet use were all associated with helmet use by children. Pendergrast and associates (1992) commented, "In the molding of children's health behavior, both modeling behavior and setting social norms and expectations are important and both of these are lacking in parents who fail to use bicycle helmets themselves" (p. 358). Placing the blame on parents' failure to adequately mentor their children serves little use except to diminish the responsibility that health care providers, and educators, have to discover a strategy that can successfully convey the importance of helmet use to all members of society. Thus, rather than focusing on what we feel we cannot change, I believe that we need to focus on those things that can potentially be communicated in a fashion that is recognizable by those we are trying to educate.

A significant problem with Pendergrast and associates' (1992) study involved a major design issue, namely their lack of an adequate tracking of pre to post test responses. More specifically, the number of respondents in the intensive (experimental) school varied from 209 children and 125 adults pretest, to 184 children and 132 adults post-test. Corresponding sample sizes in the traditional (control) school were 470 children and 364 adults at pretest, to 391 children and 336 adults at post-test. Moreover, this data was not able to be abstracted from the provided tables and descriptive summaries.

Pendergrast and associate's recognized the basic limitations their failure to adequately design a method for tracking survey respondents from pre to post-test created. Issues addressed included an inability to decipher the success of the bike safety information disseminated to the students, and the subsequent sample size and intervention effects. However, they did not believe that "forces affecting response rates acted differentially in the two (intensive and control) schools," (p. 357). This belief may be imprudent and challenged by survey researchers. In his book, "Sample survey principles and methods," Vic Barnett cautions that non-response errors may be attributed to a myriad of reasons, one of which he explains accordingly, "If the variable Y is strongly correlated with tendency for non-response (e.g. perhaps the more highly paid will be least inclined to reveal their incomes) we might expect to encounter serious bias as a result of non-response," (p. 58).

In the case of bicycle helmets, a greater likelihood exists that non-helmeted wearers would be more likely than helmeted wearers to not respond, due to the noted impact that issues related to "socially desirable" behavior have on survey responses (Fowler 1993). Thus, non-responses may place severe limitations on the inferences made from the survey responses. In order to accurately, and more reliably, infer systematic differences to the population as a whole, the researcher needs to be able to examine the effects non-responses have on the data (Barnett 1991; Fowler 1993). Pendergrast and associate's (1992) were unable to conduct any such evaluations, due to their failure to track responses from pre to post-test. Moreover, it prevented precise estimates of effect size from being calculated for data synthesis techniques.

With the assistance of a marketing firm, Puczynski and Marshall (1992) conducted a random telephone survey of parents with children aged 5-15 years residing in 5 adjacent Pittsburgh counties. All counties were exposed to the community awareness campaign implemented by the authors, and described above. Among the 500 parents surveyed, 26% stated that their child owned a helmet. Unlike Pendergrast and associates (1992) who reported that socioeconomic consideration did not effect their outcome, a negative association was noted between family income and parental years of education, and helmet ownership. Specifically, 21% of families with and annual income under $25,000 per year, 21% of families whose principal wage earner attained a high school degree or less, and 19% of families whose main wage earner never completed a college degree, had children who owned a helmet. In comparison, 34% of families earning greater than $50,000 per year, and 59% whose primary wage earner was a college graduate, had children who owned a helmet. This inverse relationship between socioeconomic issues, including highest level of education attained by parents, and helmet ownership is not new. Rather, it was previously noted by (Rivara et al. 1994; Puczynski and Marshall 1992; DiGuiseppi et al. 1990; Eichelberger et al. 1990; DiGuiseppi et al. 1989; Wasserman et al. 1988). Puczynski and Marshall (1992) report the leading reasons parents cited for why their children did not own a helmet were: "never thought about it," perception that the child would not wear a helmet or was either too young or too old to don a helmet, or simply because they "had not gotten around to purchasing a helmet" (p. 1466). These explanations of helmet non-ownership were noted by various other researchers, as were the following reasons reported by parents seeking to explain why their child was not wearing a helmet that they currently owned: 1.) riding a short distance, 2.) dislikes or refuses to wear the helmet, 3.) peers do not wear helmets, and 4.) forgets (Rodgers 1995; Runyan et al. 1991; DiGuiseppi et al. 1990; Wasserman et al. 1988).

In their follow-up survey one year after the campaign's implementation, Puczynski and Marshall (1992) found that 23% of parents were aware of the campaign. Of those that recalled the campaign, 18% stated that it influenced their decision to purchase a bicycle helmet for their child (Puczynski and Marshall 1992). Analysis of the school program 6 months post its implementation, revealed that children exposed to the educational program plus free helmet distribution, were more likely to report wearing a helmet (73%) than children exposed only to the community awareness campaign (23%). In addition, the inverse relationship noted by others between grade level and helmet use, was also evident in this study (Cote et al. 1992; Dannenberg et al. 1993; Weiss et al. 1992). Among the case children given a free helmet, 65% of the children aged 10 years or more, reported wearing their helmet. In comparison, 82% of children less than 9 years of age reported wearing their helmet ($p < 0.01$). While a similar pattern was noted in the control school children, the proportion of children reportedly wearing a helmet was less. Thirty-eight percent of all children less than 9 years and 27% of the children older than 9 years, reported wearing a helmet.

The importance of this study lies not only in its reported success rate among young children, but also in the demographic characteristics of the two inner city schools selected. Reportedly, 65% of all students were minorities, and 75% of the students were enrolled in the school's lunch assistance program (Puczynski and Marshall 1992). Equivalent male-female ratios were also documented. Unlike many studies, and the parental survey component of this study, the chosen schools were apparently not comprised of primarily white, upper-middle class children. This study included all children, with an emphasis on minorities, and found promising results. The campaign reportedly cost approximately $50,000 to implement during the first year. Whether many inner city schools have the finances to support a similar program is unknown. However, incorporation of the bicycle curriculum by the Bicycle Federation of America together with a free helmet distribution program, as done by Puczynski and Marshall (1992) may be the component that other less successful campaigns are lacking.

Not unlike Puczynski and Marshall (1992), Liller and associates (1995) also conducted a community-wide campaign to assess the effectiveness of an intense school educational program. However, the community program appeared to solicit less media (television and radio) involvement, and implored no assistance from professional athletes. Another important distinction between the two studies, was that Liller and associates (1995) targeted kindergarten and preschool children, rather than elementary and middle school children. Liller and associates (1995) report that over 23,000 community awareness-related information was distributed. Results from the local toy store reveal that 244 children's bicycle helmets were purchased with program-specific discount coupons. This reportedly corresponded to a 13% increase in youth helmet purchases over the previous year's sales.

Although this study provided some information that may relate to program success, not enough information was provided in order to determine effectiveness. Furthermore, as is commonly noted, helmet ownership does not always correlate well with helmet use (Liller et al. 1995; Schneider et al. 1993; Dannenberg et al. 1993; Cote et al. 1992; Puczynski & Marshall 1992; Fullerton and Becker 1991; DiGuiseppi et al. 1990; Kimmel and Nagel 1990; Wasserman et al. 1988; Kiburz et al. 1986; Sgaglione et al. 1986). A subsequent observational study may have provided additional insight into the effectiveness of this community campaign. An additional limitation of this study was the conductance of its observational component solely in an upper-middle class, primarily white community. Extension of a follow-up observational study to include children from all socioeconomic backgrounds, as reportedly attended the targeted preschool, may also have been beneficial.

Like the previous three studies, Schneider and colleagues (1993) implemented a community-wide coalition advocating the use of bicycle helmets. The campaign included television and radio public service announcements, direct mail and telephone communication, and a local bicycle rodeo where helmet subsidy coupons were distributed. Two separate sets of regression analyses to test for mediating relationships were performed, to distinguish between parental attitudes alone, and the parent-child dyad (Schneider et al. 1993). The first mediator model included the mediator (parental helmet effectiveness beliefs), the independent variables (the campaign components), and the dependent variable (child helmet ownership). The second mediator model was comprised of the mediator (parental worry), the independent variables (the campaign components), and the dependent variable (child helmet ownership).

Analysis of the first mediator model revealed no association between "parental helmet effectiveness beliefs" and any of the "campaign components." Because the first criteria for the test of mediation was non-significant, further analysis of this model was appropriately discontinued. Two of the four campaign components, physician advice ($p < 0.001$) and telephone communication ($p < 0.01$) were found to be significantly related with parental worry in the analysis of the second mediator model. Accordingly, analysis was continued to evaluate the next phase of the mediator model, that is, whether or not the mediator (campaign components) was associated with the dependent variable (child helmet ownership). Once again, both physician advice and telephone communication were found to be significantly associated with helmet ownership ($p < 0.05$). Thus, the last phase of the mediator model was tested by evaluating whether or not the dependent variable (child helmet ownership) was associated with both the mediator (parental worry) and the independent variables (physician advice and telephone communication). The results of that regression analysis revealed that the mediator (parental worry) remained significant, while the two independent variable (physician advice and telephone communication) were no longer significant. This suggests that parental worry of bicycle accidents may be a mediator in the association between the two interventions (physician advice and telephone communication) and the dependent variable (child helmet ownership).

Although the above findings support a multi-component approach to bicycle safety education, and have been shown to have an influence on helmet ownership through the use of a mediator model, their effect appears limited as evident by the decrease in the percentage of parents who reported that their children owned a helmet. The pre-campaign survey revealed that 31% of the parents with more than one child, stated that at least one of their children owned a helmet, in comparison to 15% of post-campaign respondents. Similarly, 21% of all pre-campaign respondents indicated that their children owned a helmet, versus 12% of post-campaign respondents.

An important distinction between Schneider and colleagues (1993) study, and other studies, was that the outcome variable was helmet ownership and not helmet use. Many of the previous studies have indicated that both children and adults who reportedly own helmets, do not necessarily wear them (Liller et al. 1995; Dannenberg et al. 1993; Cote et al. 1992; Puczynski & Marshall 1992; Fullerton and Becker 1991; DiGuiseppi et al. 1990; Kimmel and Nagel 1990; Wasserman et al. 1988; Kiburz et al. 1986; Sgaglione et al. 1986). Furthermore, the factors associated with the predisposition of some parents to "worry" were not addressed, and may have effected their choice to purchase a helmet when prompted by physicians or telephone information (Schneider et al. 1993). However, valuable information may be inferred from the results of this study regarding the type, and presentation, of information that procures the attention of parents.

The results of the first of two studies published by members of the Injury Prevention Center at John Hopkins University in Baltimore, Maryland, suggested an increase in helmet use among Howard and Montgomery County child cyclists, but a decline in the proportion of child cyclists in Baltimore County who donned a helmet. Baseline data supported previous studies that adults were more likely to wear a bicycle helmet than children (Rouzier & Alto 1995; Rodgers 1995; Frank et al. 1995; Spaite et al. 1991; Wasserman et al. 1990; Wasserman et al. 1988; Tucci and Barone 1988; Watts et al. 1986). Cote' and colleagues (1992) reported that 57% of all individuals over the age of 16 years were observed wearing a helmet at baseline, in comparison to 9% of children less than 16 years. The overall increases in helmet use for each of the three counties were: 1.) Howard

County, 3/69 (4%) of bicyclists observed at baseline, versus 24/51 (47%) of bicyclists observed at follow-up, 2.) Montgomery County, 11/140 (8%) of observed baseline bicyclists, versus 19/102 (19%) of observed follow-up bicyclists, and 3.) Baltimore County, 7/37 (19%) of bicyclists observed during the baseline period, versus 2/49 (4%) of bicyclists observed during the follow-up period. As anticipated, the data reported by Cote and colleagues (1993) revealed that children accompanied by adults were more likely to wear a bicycle helmet than those cycling with other children less than 16 years, regardless of county. This pattern was evident in Howard County despite the passage of legislation, as 100% of children accompanied by helmeted adults, and 86% of children accompanied by non-helmeted adults, were noted to be wearing bicycling helmets. In comparison, only 33% of children riding with other children less than 16 years, were observed wearing bicycle helmets. Cote' and colleagues (1992) felt that their findings provided evidence in support of mandating helmet legislation for all children under the age of 16 years. However, serious problems in their sampling methodology and subject population limit the extent to which their findings can be generalized to the population at large. Furthermore, the greatest percentage of children observed wearing a helmet were those riding with their parents. A large number of children riding alone or with other peers, reportedly continued to ride their bicycles without a helmet, in spite of the legislation mandating their use. Thus, the children living Maryland Counties with existing helmet legislation, continued to defy the law in the absence of a parental authoritative figure, regulating their decision.

Unlike the study conducted by DiGuiseppi and associates (1989), the observers did not appear to receive a thorough training program, nor were actual practice sessions conducted. Thus, as acknowledged by Cote' and colleagues (1992), their observational methods were very imprecise. Additionally, the longer observational period, 45 minutes in this study in comparison to both DiGuiseppi and associates (1989) and Liller and associates (1995) who conducted 20 minute observational data collection sessions, may have decreased the ability of the observers to recognize the same child more than once, thereby increasing the possibility of counting the child twice. Socioeconomic disparities between both Howard and Montgomery Counties and Baltimore County also need to be considered. The median income for Howard and Montgomery Counties were $57,000 and $58,900, respectively. In contrast, the median household income in Baltimore County (excluding Baltimore City) was $40,600. The discordant median family incomes, together with the predominately white communities, 83% of Howard County, 77% of Montgomery County, and 85% of Baltimore County (excluding Baltimore City), limit any inferences that may be made to the population at large. This notion is supported by the racial distribution of all cyclists observed, irrespective of county: 84.8% white, 10.2% black, and 5.3% other. Of the 25 black children observed at baseline, and the 13 black children observed at follow-up, none were observed wearing helmets. This led Cote' and colleagues (1992) to conclude that whites were more likely to wear a helmet than members of other races. However, the small number of non-white cyclists reportedly observed, raises questions about whether or not that conclusion it is justifiable. Moreover, because race-specific income data was not provided, nor was parental educational level, the potential that these factors may have confounded the observed helmet use rates is unknown. At best however, it may provide support to prior recommendations that strategies need to be undertaken to increase the bicycle helmet awareness among minorities.

The second more thorough study involving the three Maryland County communities was conducted by Dannenberg and colleagues (1993), who aimed to evaluate bicycle safety and helmet use separately in each of three Maryland Counties. The progressively more intense county programs ranged from no intervention (Baltimore County), to legislation mandating all children less than 16 years to wear a bicycle helmet (Howard County). Dannenberg and colleagues (1993) sought to accomplish their goal through the examination of children's perception regarding bicycle helmets, and their self-reported use of them. Children in grades 4, 7, and 9, and their parents, were surveyed via a mail survey. Dannenberg and colleagues (1993) found that the majority of students in all grades, and in all counties, reported owning a bicycle. Percentages ranged from 94% to 98% among forth graders, 89% to 94% among seventh graders, and 86% to 90% among ninth graders. Slightly higher percentages were noted among children who reported riding a bicycle, versus owning a bicycle, with percentages ranging from 89% to 97%. This discrepancy may reflect children sharing bicycles with other siblings, or riding friends' bicycles. Forth graders reportedly rode their bicycles significantly more than ninth graders, 91% versus 66%, respectively, ($p < 0.0001$).

The percentage of children who reportedly owned and wore bicycle helmets varied according to county and grade level. Bicycle helmet ownership was significantly higher

($p < 0.001$) in Howard County which passed a law mandating their use in 1990, in comparison to the other two counties (Dannenberg et al. 1993). The proportion of Howard County students that owned a helmet ranged from 28% to 75%, and was inversely related to grade level. The percentage of students owning helmets in the other two counties followed a similar inverse relationship with grade level, with ownership in Baltimore County ranging from 16% to 30% and ownership in Montgomery County ranging from 8% to 34%. However, as noted in the earlier studies, the percentage of students who wear a helmet, is typically less than the percentage who own a helmet (Liller et al. 1995; Macknin & Mendendorp 1994; Schneider et al. 1993; Cote' et al. 1992; Pendergrast et al. 1992; DiGuiseppi et al. 1990). This characteristic in helmet ownership was evident among all grade levels, and in all counties. Among all bicyclists, the percentage of students who reportedly wore their helmet the last time they rode their bicycle ranged from 12% to 56% in Howard County, 9% to 17% in Baltimore County, and 4% to 20% in Montgomery County, with similar inverse relationships between helmet usage and grade level as previously noted between helmet ownership and grade level. Comparable relationships and proportions were also noted in all counties, among helmet owners who reported wearing a helmet when bicycling during the last month (Dannenberg et al. 1993). Modifications in helmet use among the children residing in each of the three counties who reported wearing a helmet "always" or "usually," showed an increase from 1990 to 1991. Among these children, the proportion of helmet use in Baltimore County reportedly increased from 7% to 11% ($p < 0.001$), in Howard County from 11% to 37% ($p < 0.0001$), and in

Montgomery County from 8% to 13% ($p < 0.01$). Forth graders in Howard County reported the highest increase in helmet use between 1990 and 1991, from 24% to 61%. In comparison, the proportion of Howard County ninth graders who complied with the new helmet law increased only slightly from 4% to 15%. Although the percentage of children who wore a helmet was less in the counties without a law mandating their use, some of their percentages were noted to be higher than those among Howard County ninth graders. The proportion of Baltimore County students who reportedly "always" or "usually" wore a helmet between 1990 and 1991 increased from 11% to 17% among forth graders, and 5% to 9% among ninth graders. Correspondingly, the increase among identical students in Montgomery County increased from 14% to 20% among forth graders, but only 2% to 3% among ninth graders. Thus, it appears that in spite of legislation mandating helmet use, the majority of older children do not comply. As previously noted, risk-taking behavior, a perception of immortality or simply the rebellious nature of some youths, may contribute in part to low compliance. This postulate is at least partially supported by the finding that children who agreed with the statement, "Laws that make children wear bike helmets are good," were significantly more likely to wear a helmet than those who disagreed with the statement ($p < 0.0001$) (Dannenberg et al. 1993). Nonetheless, student respondents indicated that television, parents, and school were their leading sources of bicycle safety information.

Using logistic regression, Dannenberg and colleagues (1993) noted that the strongest predictors of helmet use were having friends who usually wore helmets

(OR = 8.4), belief that helmet laws were good (OR = 3.1), being in the forth grade (OR = 2.4), and residing in Howard County (OR = 2.1). These findings comply with the earlier findings of Cote' and associates (1992). Reportedly, the highest proportional increase in helmet use was documented by Cote' and associates (1992) who noted that observed helmet use increased from 4% in 1990 to 47% in 1991, among children less than 16 years of age residing in Howard County, Maryland. Comparably, Dannenberg and colleagues (1993) noted that forth graders in Howard County reported the highest increase in helmet use between 1990 and 1991, from 24% to 61% among all participating forth, seventh and ninth graders in each of the three Maryland Counties. The distinction between the two studies was that the former was an observational study, and the latter a self-report survey.

Dannenberg and colleagues' (1993) finding that the compliance rate among 9th graders in Howard County, Maryland, was fairly equivalent to that of children residing in the both Montgomery and Baltimore Counties, raises questions regarding the age of the subject population in Cote' and associates' (1992) study. Cote' and associates (1992) published the highest bicycle helmet compliance rate, an increase from 4% to 47%, reportedly thereby demonstrating the efficacy of bicycle helmet legislation. However, Cote' and associates did not report the actual age of their subjects, rather they categorized subjects as less than 16 years of age, and 16 years of age or older. Based on the above findings of Dannenberg and colleagues (1993), who surveyed students from the same counties that Cote' and associates (1992) observed the bicycle helmet usage patterns in, one plausible explanation for the high compliance rate noted by Cote' and associates (1992), is that they observed a significantly greater number of younger children; i.e., children in grades 7th or less. Evidence for this postulate is provided by several other researchers who noted a similar inverse relationship among age, or grade level, and helmet usage (Puczynski and Marshall 1992; Dannenberg et al. 1993; Rouzier and Alto 1995). Thus, it may not be that legislation mandating helmet use was profoundly superior to other types of helmet usage programs, as suggested by helmet advocates, rather the notable increase reported by Cote' and associates may simply be attributed to the age of the observed subjects.

The studies conducted by both Cote and associates (1992) and Dannenberg and colleagues (1993) have demonstrated the potential effectiveness of both education and legislation in increasing helmet compliance among young, upper-middle class, white children. The exclusion of lower socioeconomic families was recognized by Cote' and associates (1992), but reportedly could not be assessed due to the relatively few number of such census tracts in Howard County. Accordingly, any inferences made from these studies should focus on the benefit the programs may hold for children residing in communities with similar socioeconomic and ethnic distributions.

Like Cote and associates (1992) and Dannenberg and colleagues (1993), Macknin and Medendorp (1994) assessed the effect of helmet legislation and bicycle educational safety programs, on helmet use in four adjacent communities in Cleveland, Ohio. As expected, self-report helmet use was highest in the Beachwood community (67.6% helmet use) where both helmet legislation and an active bicycle educational program were present.

In comparison, the largest proportion of bicyclists in the Orange County community (a community which had a similar bicycle helmet legislation as Beachwood, but reportedly no educational programs), reported that they never wore a helmet (39.7%), while 37.2% reported they always wore a helmet, and 21.7% reported that they sometimes wore a helmet. In contrast, both the Moreland Hills and Pepper Lake communities reportedly had neither a current legislation nor an active educational program. Student self-reports of helmet use in both of these communities were relatively equivalent with 52.4% of Moreland Hills and 43.9% of Pepper Lake students stating that they never wore a helmet, versus 17.9% of Moreland Hills students and 21.5% of Pepper Lake students professing that they always wore a helmet.

Macknin and Medendorp (1994) demonstrated that legislation, together with a comprehensive bicycle education program, appears effective in getting young children to don a helmet. However, various factors may have contributed to this above average observed helmet compliance rate among Beachwood students (83%). The relatively high socioeconomic status, low minority rate, and a small sample population with a forth grade median grade level, are three factors that have been shown to be positively associated with helmet compliance (Wasserman et al. 1988; DiGuiseppi et al. 1990; Puczynski and Marshall 1992; Cote' et al. 1992; Dannenberg et al. 1993; Rouzier and Alto 1995). Conversely, studies with subjects residing in lower socioeconomic communities, with a higher percentage of minorities, and subjects comprising a wider range of ages, have not found such promising compliance rates (Rodgers 1995; Frank et al. 1995; Rivara et al.

1994; Spaite et al 1991; DiGuiseppi et al. 1990; Eichelberger et al. 1990; Wasserman et al. 1988; Tucci & Barone 1988; Watts et al. 1986). Viable reasons for this discrepancy may include lack of community and educational funds to support comprehensive programs, more exigent community issues such as violence and substance abuse, and a choice by medical and educational sponsored programs to not want to initiate programs in depressed areas possibly due to fear, or some other reason. Whatever the reasons may be, it remains evident that the preponderance of programs, and especially those that have instituted or recommended the development of compulsory helmet laws, have not adequately researched or analyzed bicycle-related injuries or helmet usage patterns in all communities of our society.

Like other multi-faceted bicycle helmet campaigns, the campaign devised by Rouzier and Alto (1995) in Grand Junction, Colorado also demonstrated effectiveness. The campaign consisted of a two phase bicycle helmet program, along with an educational component. Discount bicycle helmets made available via the contributions of various community members and a very generous sporting goods retailer, formed the basis of the bicycle helmet program. The educational program involved community leaders (media, health care, judiciary) and a curriculum devised by the Denver based Headstrong organization. The success of the campaign was demonstrated not only be the number of helmets purchased, but also by the observed increase in helmet use among all age groups.

A total of 6400 bicycle helmet subsidy coupons were redeemed in the Grand Junction community, a community of 76,000. Moreover, a highly significant overall increase in bicycle helmet use was observed pre to post intervention ($p < 0.00000005$). Prior to the implementation of any intervention, Rouzier and Alto (1995), via the assistance of a trained medical student, observed cyclists at 23 locations in the Grand Junction area. A total of 171 cyclists were observed in 1992, 177 in 1993, and 140 in 1994. Seventeen of the 171 (9.9%) cyclists observed in 1992 were wearing helmets. Cyclists estimated to be 21 years of age or older appeared most likely to don a helmet, as 11/38 (28.9%) were noted to be wearing a helmet. In comparison, 2/62 (3.2%) of cyclists estimated to be 14-21 years of age, and 4/91 (5.6%) of cyclists estimated to be 5-13 years of age, were observed wearing bicycle helmets.

The association between age and helmet use observed in 1992, was also observed in 1993 and 1994. The proportion of cyclists observed wearing helmets was highest among cyclists estimated to be 21 years of age or older, 41.2% (28/68) in 1993 and 47.1% (33/70) in 1994. Elementary and middle school children estimated to be between the ages of 5 and 13 years, the target population of this community campaign, also showed an increase in helmet use. While the total proportion of these children observed wearing a helmet was less than that of adults (>21 years of age), the increase in helmet use for this population over time, was significant ($p < 0.0035$). Helmet use among these children increased from 5.6% in 1992, to 12.5% (9/72) in 1993, to 30% (9/30) in 1994.

Helmet use among individuals estimated to between the ages of 14 and 21 years, fluctuated over the course of the study period. In 1992, 3.2% (n=2) of 62 individuals estimated to be in this age group, were observed wearing a helmet while cycling. Helmet use declined in 1993, as none of the 37 observed cyclists estimated to be in this age group were wearing a helmet while cycling. However, among the subjects estimated to be 14-21 years of age, the proportion of subjects observed wearing helmets while cycling notably increased to 25% (10/40) in 1994. This age group of subjects registered the most significant increase in helmet usage over time ($p < 0.00006$), despite the authors report that, "No intervention was attempted for the 14 to 21 year-old age group, as this age was believed to be the most difficult on which to have an effect regarding use of helmets" (p. 285).

Although the authors sought to observe more child cyclists than adult cyclists, the reverse was true. They postulated the reason for this variation may be due to the nature of the observation periods themselves. The authors noted that although the location of the observation periods remained constant throughout the study, the time of the observation period was permitted to fluctuate. Furthermore, late afternoon observation time periods reportedly favored adult versus child cyclists. Noteworthy, the success of this program occurred without the passage of any local legislation mandating helmet use, and appeared to have an positive effect on the adolescent and teenage population -- the population most difficult to reach. The authors explicitly stated:

> "Although some of the most extensive improvements in helmet use have occurred in communities where legislation has come into effect, the residents of western Colorado are very resistant to any legislative efforts that might limit their personal freedom or habits; Headstrong West believes that trying to initiate a helmet law

could be counterproductive" (p. 286).

The success of this program without the implementation of helmet legislation, but rather a substantial subsidy provided to customers, along with community and medical education, is an important consideration. The ability to increase a community's helmet usage without the instillation of legislation or financial penalties, typically perceived to infringe upon individual rights, demonstrates what can be accomplished when residents are involved in, rather that informed of, community interventions.

Summary

Each of the above bicycle-safety programs focused on measures to increase bicycle helmet use. Joint education and community campaigns, and legislation, or some combination of the two, were the most prevalent primary program components, with program complexity and target audience being factors that were frequently manipulated. Education emerged as the one essential component that all programs required for positive results. Affordable helmets, via program supplied subsidy coupons, was a component that was found to be effective in enticing the leery buyer, whose principal obstacle was cost.

All of the above bicycle-helmet campaigns have shown some effect on increasing helmet use. However, the most successful programs appear to be those that are aggressively implemented and multifaceted. Nonetheless, uniting all of the necessary components and personnel to successfully implement an effective campaign, and having the ability to maintain the program for long-term success, appears most challenging.

Research has shown that parents identify physicians as the most influential person in their lives regarding health related issues (DiGuiseppi et al. 1989; Eichelberger et al., 1990; Schneider et al. 1993), while children often site their parents, peers and teachers (Eichelberger et al. 1990). Despite this, Weiss and Duncan (1986) and Ruch-Ross & O'Connor (1993) discovered that less than 10% of physicians (primarily pediatricians) routinely discuss bicycle safety and helmet use with their patients or their patients' parents. In lieu of the fact that neurosurgeons and orthopedic surgeons are primary supporters of medically initiated injury prevention campaigns, it would appear that education of some of their colleagues is necessary, so that comprehensive medical campaigns can be successfully implemented. Furthermore, since pediatricians are the physicians caring for children on a routine basis (acute illness and physical examinations), it seems reasonable to expect that they be actively involved in the preventative education of our youth and their parents.

Published results suggest that community-wide campaigns that incorporate educational measures with legislation mandating helmet use, are the most successful (Cote' et al. 1992; Dannenberg et al. 1993; Macknin & Medendorp 1994; Hatziandreu et al. 1995). The Howard County, Maryland program being the most frequently cited successful program of this type, with the highest reported increase in helmet usage rate from 4% to 47% published to date (Cote' et al. 1992). However, a subsequent publication utilizing the same sample communities, raises questions about the age of the subjects in the initial manuscript, and thus the overall benefit of legislation (Dannenberg et al. 1993). The latter publication indicated that the success of the program was most notable among younger children (4th graders), while results showed that the majority of older children (9th graders) did not comply with the legislation.

Alternately, the Harborview Children's Bicycle Helmet Coalition developed by the Harborview Injury Prevention Center in Seattle, Washington, is probably the most frequently cited, and reproduced, comprehensive community-wide bicycle helmet campaign. Reported success rates include an increase in helmet use among children estimated to be 5-15 years of age from 5.5% in 1987, to 33% in 1990 (DiGuiseppi et al. 1989; Hatziandreu et al. 1995). A more recent program, reported by Rouzier and Alto (1995), involved the community of Grand Junction, Colorado. Recognizing, and respecting, the community's position against bicycle helmet legislation, Rouzier and Alto worked cooperatively with community members (media, health care, police, schools, etc.), to devise a multi-faceted community involved campaign. The success of the program was demonstrated in the overwhelming number of bicycle helmets purchased (6400), and used by the by cyclists. Observed helmet use patterns increased from 5.6% in 1992 to 30% in 1994 among children aged 5-13 years, from 3.2% to 25% among adolescents and teenagers aged 14-21 years, and from 28.9% to 47.1% among those aged 21 years and older.

Although the two above programs, those implemented in the Maryland Counties and in Seattle, Washington, report impressive success rates, they also possess a number of notable limitations. Both of these programs were implemented in predominately white, middle and upper-middle class communities, whose residents were highly educated, and belonged to above average socioeconomic levels (DiGuiseppi et al. 1989; DiGuiseppi et al. 1990; Bergman et al. 1990; Rogers et al. 1991; Cote' et al. 1992; Dannenberg et al. 1993; Schneider et al. 1993; Macknin & Mendendorp 1994; Liller et al. 1995). In addition, the greatest success rates were found among children less than 15 years of age. Separately, all of these factors have been shown to be positively associated with helmet usage (Wasserman et al. 1988; DiGuiseppi et al. 1990; Rogers et al. 1991; Cote' et al. 1992; Dannenberg et al. 1993; Schneider et al. 1993; Macknin & mendendorp 1994; Liller et al. 1995). Together, all of these factors may provide potentially misleading helmet compliance rates, and thus require prudence when making nationwide generalizations.

An additional limitation of some of the above studies is the outcome measure being assessed. Using observed helmet use as the measure of outcome has the potential to be complicated by a myriad of factors. Observed helmet usage rates are dependent upon observer reliability factors including, multiple countings of the same individuals in a given time period, the ability to ascertain the correct age and race of the observed individuals, time of day and week variations, as well as seasonal variations. Members of the Seattle helmet campaign attempted to control for many of these potential confounders by providing training sessions for all observers, randomly selecting observation sites based on three income tertiles with further divisions made according to the number of children residing in each tertile, limiting the observation period to 20 minute intervals, and using the same sites for observation over the course of the study period. A similar thorough training program was not provided to volunteer observers used in the observational phase of the

Howard County study, and a longer (45 minute) time period was utilized (Cote' et al. 1992).

Of all of the observational studies reviewed, only one study incorporated lower income and minority families (Puczynski & Marshall 1992). Moreover, of those studies which focused on middle and upper middle class, primarily white neighborhoods/counties, the lowest compliance rates were noted among the lower socioeconomic levels and minorities comprising these samples (Cote' et al. 1992). This led researchers associated with the Maryland County studies to conclude that whites were more likely to wear a helmet than members of other races (Cote' et al. 1992). A deduction that may not be justifiable due to the small percentage of non-whites included in their analysis.

The exclusion of lower income families and minorities from the vast number of successful bicycle campaigns, when these individuals have been shown to be at greatest risk and in need of most education, seems to be an serious oversight on the part of researchers, which may potentially have significant consequences (Kraus et al. 1986; King 1991; Largo & Thacher-Renshaw 1993). Therefore, the passage of legislation mandating helmet use for all individuals (or all children), inclusive of those excluded from study, based on the success rates of families who not only have a better understanding of the need for helmets, but probably more important, can afford them, is not indicative of good study design. These facts, together with the nationwide statistics that reveal that the fatality rate for bicycle-related traffic accidents has remained essentially unchanged since 1980, while bicycle usage has reportedly increased dramatically over this same time period, raises questions as to whether mandatory helmet use is necessary (Rodgers 1994; U.S. Department of Transportation 1980-1995).

Cost Effectiveness of Bicycle Helmet Usage

This final section, "Cost Effectiveness of Bicycle Helmet Usage," examines the effect of several factors on the reported costs of bicycle-related injuries. It includes the sample selection, hospital costs with attention given to types of injuries, ICU versus non-ICU admissions, and length of hospital stay. Costs associated with various injury prevention strategies will also be examined. Information in this section will not be included in any statistical analyses performed. The primary purpose of incorporating this material into this manuscript, is to allow for and informed discussion of related ancillary factors typically voiced when helmet legislation is an issue. Awareness of the limitations of such reports, is crucial to the accurate depiction of its role in making legislative decisions. Therefore, the information provided in this section will be referenced in the discussion of results, conclusions, and recommendations for future publications related to this topic.

The choice of sample population and the type of injury being examined both effect the resulting costs. Examples of two common sample biases are the exclusion of out-patient and emergency room only data in the examination of primary care hospital data, and the combined use of primary and tertiary care data (Waller, Skelly, Davis, & Herreid 1994). The consequence of the former is that it generally increases the costs of certain injuries, for example head, back and lower-extremity injuries. This occurs as more emphasis is placed on patients with higher AIS categories and head injured patients (Waller et al. 1994). The latter bias, inclusion of tertiary-care patients with primary care patients, has been shown to elevate the severity and costs associated with other injury types, namely head, trunk, and back injuries (Waller et al. 1994). Moreover, in the assessment of road transportation injuries, both forms of sample bias have been noted to accentuate the injuries resulting from motor vehicle collisions (Waller et al. 1994). Accordingly, both of these common sample biases are important in the review of bicycle-related injuries, because not only are head and lower extremity injuries commonly associated with more severe bicycle-related injuries, but the majority of severe bicycle-related injuries have been found to result from bicycle-motor vehicle collisions. Thus, it is crucial that readers are aware of the biases inherent in the samples chosen to report the medical costs for these injuries, so that the adequacy of the reports can be determined. Waller and colleagues (1994) appropriately reminds us:

> Data sets developed to meet the needs of hospital administrators and staffs often are used inappropriately to describe the frequency, characteristics, costs, and effects of injury in the population at large, and such data then serve as the basis for community-wide programs in the erroneous belief that they describe the events, conditions, or results that are most frequent, serious, or costly. In our opinion, a sample that is limited to primary care patients and that includes both nonhospitalized and hospitalized patients is the only type of sample that is reasonably capable of serving that purpose. (p. 644)

With this mind, a review of studies that reported bicycle-associated hospital costs and predicted cost-effectiveness of helmet use, will be presented. Articles are reviewed according to two primary themes: 1.) economics of bicycle trauma, and 2.) cost-effectiveness of bicycle-related injury prevention programs. Detailed descriptions of the purpose and sample acquisition were presented in prior sections of this manuscript. To avoid repetition and unnecessarily increasing the length of this manuscript, please refer back to the appropriate section or the original reference, if more detailed information is desired.

Economics of Bicycle Trauma

Watts and associates (1986), in cooperation with the emergency department staff at the Boulder Community Hospital, and the city department of public works division of transportation, requested all patients seeking treatment for a bicycle-related injury from April 1, 1983 through September 30, 1983 complete a questionnaire detailing more precisely, the events surrounding their bicycle accident. A family member or hospital personnel assisted if necessary. Watts and associates (1986) noted that 226/253 (89.3%) of the injured bicyclists had completed admission forms specifying the injuries identified in the emergency room. Helmets were reportedly worn by 33 of the 226 riders (14.6%). In comparison, 182/226 (80.5%) did not wear a helmet, and 1/226 (0.4%) wore a leather helmet. No information was presented on the remaining 10/226 (4.4%) patients. Of the 226 patients, 18 (7.9%) were admitted for overnight observation. Closed head injuries were sustained by 3/33 (9.1%) patients wearing a hard helmet, and 26/182 (14.3%) bicyclists that wore no protective head gear. No patient wearing a hard helmet was admitted for overnight observation. In comparison, 6/26 (23.1%) patients wearing no helmet required hospitalization. One of these patients incurred the highest hospital expense at $30,000, which included his acute care and ongoing rehabilitation at an area facility (Watts et al. 1986). Overall, the average hospital bill received by an injured cyclists was $328.24. More specifically, the average hospital bill for minor injuries, namely cuts, abrasions or lacerations, was reportedly $129.15. In comparison, the average hospital bill for a cyclists sustaining a more severe injury, for example, treatment for a broken bone, was $525.23 (Watts et al. 1986). No bicycle-related deaths were documented in this study

A similar study was conducted by Tucci and Barone (1988), who examined all bicyclists admitted to Saint Vincent's Hospital and Medical Center in New York from March 1984 to December 1984. The urban location of the medical center was expected to provide treatment primarily to urban cyclists. Emergency room records and follow-up telephone calls to all injured cyclists were attempted, to obtain more detailed accident information. A total of 182 bicyclists were identified, with 172 having complete hospital documentation. The costs incurred by these cyclists were reported by the emergency department. Tucci and Barone (1988) noted that all patients incurred a $65.00 emergency room bill. In addition, 75% of the bicyclists had a radiograph performed in the emergency room, the cost of which was $49.00. However, probably the most significant expenses incurred by the patients, were those associated with time lost from work. The type of injury leading to the most time lost from work was fractures, resulting in 19.9 days. Concussions were the next most frequently cited reason for lost work time, but accounted for considerably less days (7.8 days). Examination of lost work days by region of the body injured, rather than the type of injury, resulted in the following composition: lower extremity 9.8 days, lumbar spine 8.5 days, upper extremity 6.8 days, and head 6.4 days. Thus, the severity of head injuries sustained, was apparently less than injuries sustained in other regions of the body. Similar to Watts and associates (1986), no deaths were reported among this sample of injured bicyclists.

Distinct from the previous two studies, McKenna and associates (1991) examined pediatric bicycle trauma. These investigators reviewed the hospital records from a tertiary children's hospital in Cincinnati, Ohio between 1983 and 1987. A total of 201 children were admitted with bicycle-related injuries. No deaths were recorded among these children. The hospital stay incurred by injured cyclists ranged from 1 to 43 days, with an average of 3 days. However, the majority of children (72%) had a hospital stay less than 2 days. In contrast, 28/201 (14%) of the injured bicyclists were admitted to the intensive care unit, where the hospital stay ranged form 1 to 9 days, with an average stay of 2 days (McKenna et al. 1991). Unlike the two prior studies, where the mean age of the patient population was 26.6 years, and 22 years respectively, McKenna and associates noted that head injuries accounted for the majority of hospital admissions of injured bicyclists in his sample. The mean age of the child bicyclists injured in McKenna's study was 10 years. The disparities between the first two studies and the study by McKenna and colleagues (1991) may be confounded by two important factors: age, and the population of patients from which the samples were drawn. Only McKenna's patients were acquired from a tertiary facility. Neither Watts and associates (1986) nor Tucci and Barone (1988) reported data from such a facility. Accordingly, the subject population from which McKenna et al. (1991) attained his sample, was subject to all the biases mentioned above, namely, an overestimation of the proportion of seriously injured cyclists with a concomitant increase in related hospital costs.

A more detailed study of pediatric injuries was presented by King (1991). King (1991) reviewed the discharge data from the Children's Hospital of Alabama. Reportedly, the database used reflected, "45.5% of all discharges of seriously injured children less than 15 years of age" (p. 342). Once again, as in McKenna and colleagues' (1991) study, it is important to recognize that the data to follow consists largely of seriously injured children, and not all injured children. One sub-category assessed by King (1991) was pedalcycle injuries. Pedalcycle injuries were the third most common form of injuries sustained by children in this age group, accounting for 102/1077 (9.5%) of all injuries. Among those injured, 70.6% incurred their injuries in non-motor vehicle collisions, and 67.6% of all pedalcyclists sustained a skull fracture or closed head injury. Documentation of helmet use was not provided. Examination of patient injury by length of hospital stay, reduced pedalcycle injuries to sixth relative to all other causes of injury, accounting for 352 hospital days. The average hospital stay for an injured pedalcyclist was 3.5 days. The total hospital charges incurred by all injured child bicyclists were $410,752, with an average per patient charge of $3045.43.

Unlike the majority of articles to be presented here, Malek and colleagues' (1991) primary focus was the costs associated with medical care provided to children. Data was acquired from the Massachusetts Statewide Childhood Injury Prevention Project (SCIPP), and from 1987 medical claims from the Health Data Institute in Lexington, Massachusetts. SCIPP data is comprised of hospital emergency room and inpatient data from 23 hospitals located in 14 Massachusetts communities, serving 87,000 children aged 0 to 19 years, between 1979 and 1982. Charge data from the Health Data Institute consisted of "insurance claims for 3% of all privately insured patients throughout the United States" (Malek et al. 1991, p. 997). Commercial insurance companies supply 85% of the health claims compiled by the Health Data Institute. Health claim data was acquired from insurance claims between October 1986 and March 1988. In reference to SCIPP data, Malek and colleagues (1991) reported that SCIPP hospitals accounted for 93% of the inpatient treatment provided to SCIPP residents. However, similar information for emergency department visits was not known. A 25% sample for all injuries, including pedalcycle injuries, but excluding burns and poisoning, comprised the emergency room data. Sample biases of the SCIPP data, in comparison to the U.S. population that were recognized by the authors, include an over-representation of 10 to 19 year old children, and an under-representation of the following: 1.) 0 to 4 year old children, 2.) minorities, namely blacks, and hispanics, 3.) rural inhabitants, and 4.) less educated families. However, SCIPP communities were reportedly slightly poorer than the nation as a whole (Malek et al. 1991).

Among the 15 ICD-9 and E-coded causes of injury, the incidence of pedalcycle injuries varied among all age groups, as well as among inpatients and outpatients. Overall, the incidence rate for pedalcycle injuries requiring hospitalization was 5.6 per 10,000 children-year (4th among all causes of injury), in comparison to 77.8 per 10,000 children-year (7th among all causes of injury). The lowest bicycle-related injury rates were obtained for children aged 0-4 years (0.7/10,000 inpatient and 21.6/10,000 outpatient) and 15-19 years (3.2/10,000 inpatient and 41.9/10,000 outpatient). Conversely, the highest bicycle-related injury rates were reported for children aged 5-9 years (7.9/10,000 inpatient and 113.7/10,000) and 10-14 years (10.1/10,000 and 129.4/10,000). The overall mean initial medical costs for pedalcycle injuries was $4,845 for hospitalized patients and $171 for outpatients. Mean inpatient and outpatient costs ranges varied from $3,811(from 5-9 age group) to $7,509 (from 15-19 age group) for inpatients, to $141 (from 0-4 age group) to $181 (for both the 10-14 and 10-14 age groups) for outpatients. Head injuries led the injury incidence rates for inpatients among all age groups, and for all types of injuries. Furthermore, 24% of all head injuries required hospitalization.

Acknowledged limitations associated with this manuscript include: 1.) a greater likelihood to hospitalize children possessing greater injury severity, in comparison to adults, 2.) an increased hospitalization rate among Northeastern hospitals, when compared to the nation as a whole, and 3.) uniform costs were applied to a given cause of injury, regardless of how the injury occurred (Malek et al. 1991). In recognition of these limitations, Malek and associates (1991) noted that an underestimation of the national injury incidence was most likely to be the primary source of bias, resulting in a low estimate of injury costs.

Two more recent studies conducted by Jaffe and associates (1993) and Buckley and colleagues (1994) utilized hospital data from regional children's tertiary care facilities. Jaffe and associates (1993) obtained data from patients enrolled in a traumatic brain injury study of neurobehavioral outcome. The participating children presented to either the Harborview Medical Center (HMC) in Seattle, Washington, or the Children's Hospital and Medical Center (CHMC) also located in Seattle, Washington. HMC is reportedly the only level one, tertiary, trauma center servicing Washington, Alaska, Idaho, and Montana. Similarly, CHMC is HMC's counterpart children's tertiary facility servicing the same region. Thus, the very nature of the subject population leads to an over-representation of severe head injuries among all comparable head injured patients. In acknowledgment of this fact, the authors recommend that median charges, rather than mean charges, would be more representative of "typical" injury specific costs. An attempt will be made to report both costs, to show how a selected sample may erroneously portray the costs, and hence the injury severity of bicycle-related injuries.

The mean age of the total patient population was 9.8 years, with the mean age of hospitalized patients being slightly higher at 10.1 years. As expected, injuries resulting from high energy accidents, namely motor-vehicle related injuries, incurred the highest costs ($15,213 median costs, and $50,433 mean costs). In comparison, bicycle-related injuries from all causes (including bicycle-automobile collisions) resulted in a median cost of $6,311 and a mean cost of $32,280, whereas bicycle-related injuries resulting from recreational crashes resulted in a median cost of $778 and a mean cost of $2,739. Thus, the evaluation of bicycle-related injuries alone, revealed that injuries sustained by bicycle-automobile collisions accounted for the largest average median and mean costs among all bicyclists injured.

The calculation of costs according to severity of brain injury (GCS or AIS scores), reportedly increased dramatically in association with increasing severity ($p < 0.0001$). More specific regression analyses were performed to examine the role injury severity and injury etiology played in the determination of costs. Jaffe and associates (1993) noted that, "Regression analysis of the ranked cost data showed that injury etiology added modestly, but significantly, to the prediction of cost over and above that predicted by severity alone" (Jaffe et al. 1993, p. 683). The R^2 value corresponding to the model with severity alone was 0.58, which increased to 0.68 with the addition of injury etiology ($p < 0.001$ for the change in R^2, based on an F-distribution with 4,89 degrees of freedom). Equivalent R^2 values were reportedly obtained when either the abbreviated injury severity (AIS) or the Glasgow coma score (GCS) were used as an indicator of injury severity. In addition, regression analyses also revealed the overwhelming relevance of head injuries in the resulting costs of various injuries. An additional regression analysis of ranked cost data on both AIS head injury score and AIS score for other body regions, indicated that AIS head score explained 58% of the total ranked costs, while AIS score for other body regions explained 26% of the total ranked costs. Together, the AIS score for all body regions (head included) explained 66% of the variation in total ranked costs.

Helmet use among bicyclists was low, worn by 1/34 (2.9%) of all brain injured bicyclists. Cost comparison of the helmeted cyclist with the mean of the non-helmeted cyclists was $4,886 versus $33,110, respectively. The substantial disparity between the one helmeted and all the non-helmeted cyclists is evident. However, care must taken in making any important conclusions or inferences due to the extremely small sample.

Examination of children admitted to the Children's National Medical Center in Washington, DC, a designated level one trauma center for the tri-state region encompassing the urban, suburban, and rural areas of the District of Columbia, Virginia and Maryland, was performed by Buckley and associates (1994). Only those children incurring severe skeletal injuries between September 1985 and June 1988 were included in this study. A total of 3,472 children were admitted to the hospital during the study period, of which 805 sustained 953 fractures and dislocations, and comprised the subject population of this study. Injuries resulting from bicycle-related accidents constituted less than 5% of the total sample. Due to the low percentage of serious skeletal injuries sustained by bicycle-injured cyclists, detailed information of the events, length of stay and associated costs specific to bicycle-related accidents was not provided. However, it is important to note that central musculoskeletal injuries, namely spine, clavicle/scapula, pelvis injuries, and femur injuries, were related to all of the following: 1.) the longest hospital stays, 2.) the majority of ICU admissions, 3.) the highest injury severity scores, 4.) the highest hospital charges, and 5.) the highest mortality rates (Buckley et al. 1994). In contrast, peripheral injuries, particularly wrist/hand, radius/ulna, humerus, tibia/fibula, and ankle/foot, were associated with the reverse patterns indicative of less severe injuries.

A review of statewide inpatient hospital discharge data formed the subject population of the next two studies. Largo and Thacher-Renshaw (1993) acquired data from the Office of Health Statistics, Rhode Island Department of Health for 1990 bicycle-related injury hospitalizations incurred during 1990. The length of hospital stay for all injured bicyclists ranged from 0 to 58 days, with a median stay of 2 days. In comparison, the median hospital stay for all injury patients was 4 days. This is suggestive of an overall lower injury severity among bicyclists. Associated hospital costs for injured bicyclists ranged from $340 to $28,777, with a mean of $3,459. Largo and Thacher-Renshaw (1993) note that the majority (97%) of all injured bicyclists had routine discharges, with no hospital fatalities. However, a finding of immense importance in the review of data acquired from large databases, is that hospital injury admissions for bicyclists were five times more likely to be coded among those bicyclists who were fatally injured versus those with non-fatal injuries. This reflects a potentially large percentage of minor bicycle-related injuries that may not be included in the analysis of statewide data, thereby under-estimating the reported morbidity and over-estimating the reported mortality data for injured bicyclists.

Comparable to Largo and Thacher-Renshaw (1993), Chudy and associates (1995) acquired data from the Wisconsin Office of Health Care Information database for 1989 through 1993 (Chudy, Remington, and Blustein 1995). Data was reportedly available for 61% of all traumatic brain injured patients, among which bicyclists accounted for 5% of the injuries. Once again, rather than providing detailed information for bicycle-related injuries, overall information was reported. Chudy and associates (1995) demonstrated that although the number of traumatic head injuries incurred in Wisconsin has decreased each year from 1989 (n = 4655) to 1993 (n = 3156), the average charge per person has risen from $8,000 to $15,000, and the concomitant total charge per year has increased from $37,400,000 to $47,700,000. The authors suggest that this pattern may represent either an actual reduction in the incidence of traumatically brain injured patients, a tendency to care for less severe injuries as outpatients, or both (Chudy et al. 1995). The increase in length of stay from 6 to 8 days during this time period, appears to be more indicative of the latter (to treat less severe patients as outpatients). Should this be the case, and suppose Largo and Thacher-Renshaw's (1993) finding that fatal injuries due to bicycle-related accidents are significantly less likely to receive the proper injury surveillance coding than non-fatally injury bicyclists, then a large proportion of minor bicycle-related head injuries would also be excluded from such public health surveillance systems.

Lastly, Yelon and associates (1995) assessed the characteristics of bicycle trauma patients admitted to an urban trauma center in New York, between January 1, 1986 and December 31, 1994. A total of 84 bicyclists were identified, with an average age of 21.3 years. The average ISS for all patients was 13.1. The average length of hospital stay for all bicyclists was 9.15 days, with 30.9% of patients necessitating ICU admission with a corresponding average length of stay of 7.81 days. Although no specific costs were provided, a modest proportion of the subjects reportedly received specialized diagnostic tests and surgical procedures, with 11.9% requiring more than one surgical procedure. Moreover, none of the injured bicyclists were reportedly wearing any form of protective gear.

The majority of the data presented above came level one trauma, or tertiary, centers, thereby increasing the tendency to overestimate serious injuries, primarily those involving the head, back and lower-extremity injuries as they are often associated with higher severity scores (Tucci & Barone 1988; King 1991; Jaffe et al 1993; Buckley et al. 1994). Thus, as with all samples subject to bias, any inferences to the population at large must be done with prudence.

Cost-Effectiveness of Bicycle-Related Injury Prevention Programs

Three studies aimed to evaluate the cost-effectiveness of bicycle helmet programs (Thompson et al. 1993; Miller and Galbraith 1995; Hatziandreu, Sacks, Brown, Taylor, Rosenberg, & Graham 1995). Of those, two evaluated a single prevention program (Thompson et al. 1993, and Miller & Galbraith 1995), while the other assessed the efficacy of 3 recognized programs (Hatziandreu et al. 1995). Distinct from the other two studies, Miller and Galbraith (1995) sought to determine the effectiveness of pediatric counseling in the prevention of childhood injuries from various causes. This study was under-taken by the American Academy of Pediatrics, with estimated medical cost saving based on the responses from three Framingham, Massachusetts safety surveys regarding pediatric counseling of childhood injury prevention. The safety surveys were reportedly later incorporated into the American Academy of Injury Prevention Program coined TIPP. The initial program required parents to complete a safety survey while waiting to see a physician. However, this was modified to involve the distribution of safety instructions with subsequent oral questioning by the physician to assess comprehension. Through the question and answer period, the physician is to gain an understanding of the parents level of safety awareness, and clarify any issues that the parent may inappropriately possess. Although bicycle-related injury knowledge was not reported, it was included in this section as the feasibility of such counseling was addressed by both Weiss & Duncan (1986) and Ruch-Ross and O'Connor (1993) in their examination of the "knowledge and behavior of physicians."

Miller and Galbraith (1995) estimated that pediatrician initiated injury prevention counseling of children between the ages of 0 and 4 years, and their parents, would achieve estimated savings of $880 per child, or $80 per visit. These medical cost savings were derived by multiplying the estimated counseling effectiveness times spending on the average cost of injury during the child's first 5 years. Corresponding estimates were reportedly acquired from a preliminary study and were estimated to be a 15.3% reduction in childhood injuries (effectiveness estimate), with an average cost of childhood injuries equaling $394. This study apparently took place in the latter 1980's and early 1990's, although the actual time period of the study was not reported. Ideally, the concept and implementation of this study make it an attractive program to support. However, an earlier study conducted by Weiss and Duncan (1986) addressed the reality regarding the feasibility of such a study. They surveyed pediatricians and family physicians in Tucson, Arizona regarding their knowledge and counseling practices surrounding bicycle-related injuries. Surprisingly, despite the fact that 92% of the physicians acknowledged that most children do not wear bicycle helmets, and 78.9% of them believed that this behavior was most likely attributable to lack of parental awareness of their significance in the prevention of serious head injuries, only 4.5% of all physicians routinely or almost routinely, incorporated bicycle safety counseling into well-child care. In the examination of pediatricians alone (separate from family physicians), Weiss and Duncan (1986) noted that 20.6% of all pediatricians replied that they never included bicycle safety in patient education information. The remaining pediatricians indicated the following responses: 52.9% "almost never," 20.6% "sometimes," and 5.9% "almost routinely." No pediatrician routinely performed bicycle safety education. A more comprehensive examination of pediatricians' bicycle helmet counseling practices was later assessed by Ruch-Ross and O'Connor (1993). These investigators surveyed 1624 American Academy of Pediatrics members. Surveys were completed and returned by 1201 members. In comparison to Weiss and Duncan (1985), a larger proportion of all pediatricians appeared to be providing some bicycle safety counseling to parents and children. Sixty-two percent of all respondents indicated that they incorporated both helmet use, and other bicycle safety issues, into bicycling counseling of children aged 12 years or less. In comparison, 14.4% stated that they only discussed helmet usage, and 3.6% discussed relevant non-helmet issues regarding bicycle safety. Interestingly however, 20.1% reported that they did not discuss any type of bicycle safety with their patients 12 years or younger. This is surprising in light of the enormous amount of community, educational and medical programs advocating the use of bicycle helmets. Among those physicians that did discuss bicycle safety with parents and children, 45.3% only discussed it with patients 5 years of age or older.

The different manner by which the two groups of investigators sought to assess the prevalence of bicycle safety education by pediatricians, makes it difficult to compare the two studies. Weiss and Duncan (1986) inquired about the frequency of bicycle safety education among pediatricians and family physicians in Tucson, Arizona alone. They provided likert-type response choices ranging from never to routinely, and reported separate, as well as combined responses for both pediatricians and family physicians. In contrast, Ruch-Ross and O'Connor (1993) sampled pediatricians nationally. They surveyed their respondents as to whether they "ever discussed bicycle safety." The available response choices included, "no," "helmet use only," "other bicycle safety issues only," "helmet use and other bicycle safety issues." Supposing that the views of pediatricians and family physicians on bicycle safety in Tucson, Arizona were not significantly from the views of pediatricians nationwide, comparison of their responses is justifiable. However, only the first response category, "never" and "no," respectively, appear most comparable, due to the different response choices that formed the remainder of the categories in each of the two studies. Comparison of these two percentages, 20.6% (Weiss and Duncan, 1986) and 20.1% (Ruch-Ross and O'Connor, 1993), do not appear to indicate a substantial improvement in the proportion of pediatricians who provided some form of bicycle safety education information to their patients or families, over almost a decade. Thus, although physician education of parents and children may appear to be ideal, its feasibility appears questionable. In an era where physicians are required to see as many patients as possible in a given day, bicycle safety, like other types of preventative education, may assume secondary or tertiary positions, behind the immediate needs of families due simply to insufficient time and staffing.

Members of the Harborview Injury Prevention and Research Center in Seattle, Washington, continued their series of publications utilizing data from the Group Health Cooperative (GHC) of Puget Sound, a large regional HMO organization, to report the cost-effectiveness of their previously reviewed bicycle helmet campaign (Thompson, Thompson, Rivara, and Salazar 1993). Head injury rates, helmet use and associated costs were obtained for all bicycle-related head injuries sustained between December 1, 1986 and November 30, 1987. A general definition of head injury was used, specifically, "injury to the forehead, scalp, ears, skull, brain, or brainstem" (Thompson et al., p. 902). The subject population for this study included children aged 5-14 years treated at a GHC affiliated facility, and a hypothetical cohort of 100,000 5 to 9 year old GHC children. The hypothetical cohort of children was derived from an empirical data set of the incidence and costs associated with bicycle-related injuries incurred by children (Thompson et al. 1993). Head injury costs were ascertained from the medical costs billed to GHC children who incurred a head injury from all causes. Thompson and associates (1993) stated that no attempt was made to distinguish bicycle-related head injuries from head injuries resulting from all other causes, due to the technical difficulty associated with such a separation, and because "64% to 80% of serious and fatal injuries in cyclists are due to head injury" (p. 903).

Head injury rates for children aged 5-9 years and 10-14 years, applying the prevailing helmet usage rates in Seattle, Washington, of 19.6% and 8.6% respectively, were estimated to be 566 per 100,000 for children aged 5-9 years, and 377 per 100,000 children aged 10-14 years. Associated yearly head injury costs were estimated to be $150,612 and $290,418 per 100,000 age-specific children, respectively. Costs increased to $343,760 per 100,000 and $483,566 per 100,000 respectively, when catastrophic head injuries were included. Further analysis revealed that bicycle helmet subsidies of $5 and $10 would be cost-effective for 5-9 year old children, only if helmet usage rates reached 40% to 50% among children in this age group. Attainment of these rates (40% and 50% helmet usage) over a five year period, reportedly corresponded to the prevention of approximately 564 and 840 head injuries, respectively.

The potential benefit of these results need to be weighed with respect to the limitations and biases of the study. The appropriateness of including facial and ear injuries in the definition of head injuries is questionable. Since the focus of the campaigns was on the preventions of bicycle-related head injuries afforded by helmets, and because helmets do not protect these areas, inclusion of them in the definition of head injuries would only appear to raise the percentages of head injuries and their associated costs. In addition, the inability of the authors to separate bicycle-related head injuries from head injuries resulting from all other causes, is likely to further overestimate the costs associated with bicycle-related head injuries, and thus the potential cost savings. The authors felt that not incorporating the plausible reduced costs of head injuries among helmeted cyclists, would introduce conservative error, thereby minimizing the former over-estimate of head injuries. However, because the majority of studies reporting both helmeted and non-helmeted head injury data indicate a significant difference between the severity of injuries sustained by helmeted and non-helmeted cyclists, it is debatable as to whether these two factors would balance each other out (Belongia et al. 1988; Fullerton & Becker 1991; Spaite et al. 1991; Jaffe et al. 1993).

A second consideration that warrants attention is whether a 40% to 50% helmet compliance rate is attainable. Although these authors believe this usage rate is both achievable and maintainable over a period of time based on current and continued helmet use estimates among the GHC children, other studies do not support their optimism (Kimmel & Nagel 1990; Weiss 1992; Pendergrast et al. 1992; Liller et al. 1995). Programs that have documented successful helmet compliance, for example, Howard County, Maryland who enacted legislation requiring helmet use among children less than 16 years of age, have shown a reduction in helmet use among all children, especially older children, as more time passes from the original mandate (Dannenberg et al. 1993).

In additional, programs reporting the highest success rates in the form of helmet use, including this study and the study involving Howard County, Maryland, have been implemented in primarily white, upper-middle class communities. Comparable success rates have not been documented, to this author's knowledge, in lower income and impoverished communities. In following, these cost savings rely not only the attainment of 40% to 50% helmet usage rates, but also on helmet subsidies of $5 to $10. The program costs incorporated into these analyses did not include the costs associated with the development and the administration of a helmet program, only the subsidy costs (Thompson et al. 1993). Depending upon the location and available educational or private resources, these costs may not only reduce the cost-effectiveness of such a program, but make it unfeasible. Furthermore, the cost of a bicycle helmet after the reduction allotted by the subsidy coupon, may still remain too exorbitant for lower income and impoverished families. Despite these limitations, the findings of Thompson and associates (1993) provide information beneficial to large organizations, such as insurance companies and other health maintenance organizations, that may be able and willing, to undertake the initial financial responsibility to implement a similar comprehensive program, with the expectation of yielding the benefits in a reduction of medical services required to care for bicycle-related head injuries.

The most recent cost-effectiveness study to be reviewed was conducted by Hatziandreu and associates (1995). Hatziandreu and associates (1995) compared the cost-effectiveness of three prototypical programs designed to increase bicycle helmet use among children. The three programs selected were: 1.) the legislative approach inaugurated by Howard County , Maryland, 2.) the community approach developed by the Harborview

Injury Prevention and Research Center in Seattle, Washington, and 3.) the school based program drafted by Oakland County, Michigan. The first two programs have been presented in detail in previous sections of this manuscript, so their description will be limited here. Reference should be made to the earlier notations , or to the original citation if further information is desired.

The Howard County, Maryland legislative program involved the enactment of legislation requiring all children under the age of 16 years to wear a bicycle helmet when riding on all public or county roads. This mandate went into effect in July, 1990, in the predominately white, upper-middle class communities encompassing Howard County. Various county schools simultaneously implemented bicycle safety educational programs, while miscellaneous public and media campaigns were employed to promote the law. An observational study conducted by Cote' and colleagues (1992) documented program effectiveness in terms of observed helmet use rates among the targeted children. Cote' and colleagues (1992) reported an observed prelaw helmet use of 4%, which increased to 47% seven months post-enactment of the law. To this author's knowledge, this remains the highest published increase in helmet use due to a bicycle safety legislative intervention. However, a subsequent publication by Dannenberg and associates (1993) raised questions about the age of the subject population observed by Cote' and colleagues (1992), and thus the overall effectiveness of legislation in the use of bicycle helmets.

The Harborview Injury Prevention and Research Center in Seattle, Washington developed a comprehensive community-wide bicycle helmet campaign. The program aimed to increase the use of bicycle helmets among children aged 5-14 years, through the use of a multi-faceted coalition. The coalition involved three main strategies: 1.) increasing parental and community awareness, 2.) reducing the costs of bicycle helmets, and 3.) encouraging children to wear helmets. Accordingly, the campaign involved an array of educational material, endorsements by sports figures, helmet subsidy coupons, mass media efforts (television and radio, including talk shows, consumer reports etc.), various school-based activities, including bicycle rodeos and incentive coupons, and miscellaneous community organized events. Similar to both Cote' and colleagues (1992) and Dannenberg and associates (1993), DiGuiseppi and associates (1989) evaluated program effectiveness through the conductance of an observational study. DiGuiseppi and associates (1989) reported that helmet use among children estimated to be 5-15 years of age, increased from 5.5% in 1987 to 15.7% in 1988. Subsequently, Hatziandreu and colleagues (1995) reported the observed helmet use rate among Seattle children estimated to be 5-12 years of age, was 33% in 1990.

The third bicycle helmet was a pilot program implemented in 6 schools in Oakland County, Michigan. The program reportedly targeted children aged 10-14 years, and included an abundant source of educational material, helmet subsidy coupons, public service announcements, and assorted classroom activities (Hatziandreu et al. 1995). Three schools presumably executed "high-intensity" strategies, which involved the above measures, plus the utilization of sports figures and helmet giveaways. In comparison, the other three-school implemented "low-intensity" interventions, which involved only the baseline interventions, without the solicitation of sports figures at special assemblies and helmet giveaways. Unlike the previous two programs, helmet ownership and use was assessed by a pre and post-intervention telephone survey of the targeted children's parents. Helmet use 75% or more of the time, reportedly increased from 2% to 3% among children subject to the low-intensity program, versus 2% to 8% among children participating in the high-intensity intervention.

The estimated cost-effectiveness, prevented injuries and mortalities, program costs, direct medical costs, and helmet purchase costs were calculated for each of the above programs. Hatziandreu and colleagues (1995) discovered that the administration of the program itself was not the primary determinant of overall program cost, rather it was the cost of helmets. More specifically, the cost of the helmets accounted for 90% of both the community and legislative approaches' total costs, and 27% of the costs of the school-based program (Hatziandreu et al. (1995). Therefore, an important determinant of the total costs, is who is responsible for the purchase of helmets in each of the three programs. Parents (and children) were responsible for the purchase of helmets in the community and legislative program, while the school-based program purchased a significant number of helmets which were subsequently distributed to the students.

The diverse structure of the school-based program in relation to the other two programs precipitated a number extrapolations to enable this program to be compared with both the legislative and communty programs. One disparate factor that evoked descrepancy between the three programs was the targeted sample. Both the community and legislative approaches focused on children of relatively similar ages (children less than 16 years) and communities of people of similar size (approximately county size). In contrast, the school based approach directed their attention to a select group of children aged 10-14 years, who were enrolled in one of 6 schools, 3 of which received the high-intensity intervention. In order for these three programs to be compared, it was necessary to infer the costs, and expand the age groups, from a discriminate sample to a large community (Hatziandreu et al. 1995). Not only were the programs themselves different, but so were the program evaluation periods. The authors used the reported program evaluations published over the years that yielded the highest success rates of the program. Specifically, Howard County reported the highest post-law helmet compliance 6-7 months post its enactment (Cote et al. 1992). This evaluation period was the one used in this cost-effectiveness study, rather than the observed helmet usage rate published by Dannenberg and associates (1993) who showed a decline in the helmet usage rate in Howard County. Similarly, DiGuiseppi and associates (1989) reported the following success rates of observed helmet usage among Seattle children biannually over 1987 and 1988: September 1987 (5.5%), May 1988 (10.5%), and September 1988 (15.7%). However, none of these findings were used as comparison figures. Rather, Hatziandreu and colleagues (1995) reportedly used a figure published by Rogers and associates (1990) elevating the percentage of observed helmet wearers to 33% (Rogers, Bergman, & Rivara 1991). In comparison to the two above well publicized programs, the outcome measure used for assessment of program effectiveness for the school-based program was obtained only 3-4 weeks following the initiation of the program. Moreover, because the school-based program is no longer operational, additional program efficacy studies are not available. These disparities raise two important issues: 1.) should a more comparable, and operational school-based program have been evaluated by these authors, and 2.) were the selected post-program effectiveness percentages appropriate. Considering the school-based program achieved possibly the highest increase (2% to 8%) in the shortest time frame, above that reported by the Seattle program (DiGuiseppi et al. (1989) which documented a 5% helmet usage increase (5.5% to 10.5%)) over a 4 month period, selection of different, more comparable outcome time periods, may have been more appropriate and provided different results.

The assumption that the observed proportion of children wearing helmets over a 4 year period would remain the same, is also problematic. Various researchers, including Dannenberg and associates (1993) in their report on Howard County post-legislation helmet rates, noted that this was not the case (Kimmel & Nagel 1990; Weiss 1992; Pendergrast et al. 1992; Liller et al. 1995). In addition, the authors discounted the frequently reported concept of "selective helmet wearer" stating that, “We assumed that the risks of bicycle-related head injury are evenly distributed among all bicyclists” (p.257). This is a large, and definitely disputable concept, in lieu of the fact that practically all investigations and national statistics reviewed in this manuscript note that adolescents are at greatest risk. Furthermore, the opinion that individuals, especially teenagers likely to engage in risk-taking behavior, are less likely to don a helmet has been discussed by several other authors (Watts et al. 1986; Tucci & Barone 1988; Thompson et al. 1990; Kimmel & Nagel 1990;

Spaite et al. 1991; Weiss 1992; Pendergrast et al. 1992; Frank et al. 1995; Liller et al. 1995). These confounding factors and others, namely safer cyclists, white children, children with better educated parents and from the higher socioeconomic levels, are all more likely to wear a bicycle helmet than their corresponding counterparts. Another limitation of this study to be contemplated, is the head injury cost used in the cost effectiveness analyses. Similar to Thompson and associates (1993), Hatziandreu and colleagues (1995) did not use the costs associated with bicycle-related head injuries. Rather, they used the costs associated with head injuries of all causes. Again, such practices often lead to an over-estimation of cause specific costs. As noted by Waller and associates (1994) in their assessment of transportation related injuries, this places greater emphasis on more severe injuries, especially those involving motor-vehicles.

The final limitation of this study to be addressed is the authors decision to not include the cost of both legal enforcement, and parental liability for fines received for non-compliant children. Because the essence of the Howard County legislative program is the enforcement of a law, it would appear to warrant consideration. However, should the underlying intention be awareness of the existence of such legislation, rather than the actual enforcement of the laws be enough to cause children to routinely wear helmets, long-term compliance is questionable.

In spite of these limitations, Hatziandreu and colleagues (1995) concluded that the legislative approach appeared to be the most cost-effective. Reported program costs per head injury avoided for each program were: $36,643 for the Howard County legislative program, $37,732 for the Seattle community program, and $144,498 for the Oakland school program.

<u>Summary</u>

The impact head injuries have on society, both financially and through loss of individual productivity, is readily apparent to neurosurgeons and other physicians caring for head injured patients. Typically, the length of hospital stay, intensive care unit days, and related hospital charges are prominent hospital and insurance concerns. The fact that children less than 15 years of age sustain the greatest number of bicycle-related head injuries further adds to the above statistics, as it is these children's rehabilitation and potential years of quality of life lost, that will have a long term impact on society. Thus, it is no surprise that medical personnel are seeking ways to minimize the occurrence of such injuries.

However, the manner in which many injury statistics are reported, has the potential to provide misleading information. The sample population from which the data is drawn (primary care hospital, tertiary care hospital, emergency room only patients, etc.) significantly effects the reported severity levels, and subsequent hospital costs. The nature of patients treated at trauma and tertiary care facilities is positively associated with higher severity levels, and increased costs. Acknowledgement of this concept may help to explain the disparate results found between various studies.

With this in mind, review of the above studies indicate that fatally injured cyclists were more likely to be appropriately coded by hospital personnel, than were non-fatally injured cyclists (Largo & Thacher-Renshaw 1993). This may correspond to an over-estimation of bicycle-related mortalities, and an under-estimation of minor bicycle-related accidents. Traumatic head injuries were found to have decreased in Wisconsin, although the concomittent length of hospital stay, and hospital charges had increased (Chudy et al. 1995). Chudy and associates (1995) attributed this pattern to more patients being treated as outpatients. The largest study, conducted by the Harborview Injury Prevention and Research Center in Seattle, Washington, reported head injury costs that failed to separate bicycle-related head injury costs from head injuries resulting from all other mechanisms. Additionally, these researchers also based their frequently cited program success rates, on the attainment of a 40%-50% helmet compliance rate, helmet subsidies of $5 - $10.00, and did not include start-up and administrative costs into the program costs. These practices are likely to over-estimate the costs associated with bicycle-related head injuries, and thus the potential cost savings of their injury prevention program, while not adequately representing the finances required to implement such a comprehensive program.

Thus, the above findings demonstrate how important it is that researchers adequately describe how the sample population was acquired, the subject population itself, values used in the estimation of all calculations, as well as any inherent biases and limitations of their study. Likewise, it is equally important that educators, legislators, and health care providers critically review the data being presented, especially when it is used to recommend legislation that will effect everyone. Failure to include subjects (minorities and lower socioeconomic families) into studies that are used to make decisions regarding them, is unacceptable and unethical in all other areas of clinical medicine. The same standards should be upheld in injury prevention research.

CHAPTER 3

METHODS

The potential study sample was broadly defined to include all those studies reporting the incidence or severity of bicycle-related injuries or fatalities, effectiveness of bicycle safety programs, bicycle helmet usage, or some combination of the above. The decision to formulate a very general research question, thereby encompassing a wide range of constructs, was done to increase the availability of viable studies. It was felt that because the majority of studies in this area of research included nonrandomized quasi-experimental studies, which are typically methodologically weak when compared with randomized controlled studies, that selectivity of quality studies from available studies would be a complicated issue.

Search Procedures

Three primary procedures were employed to identify studies: computer searches, bibliographic reviews, and governmental requests. Computer searches of *Medline, Educational Resources Information Center (ERIC),* and *Article List* (a sub-component in the *First Search* database). Relevant substantive and research search terms included: accidents, motor vehicle accidents, traffic accidents, bicycle accidents, bicycling, head injury (ies), spinal cord injury (ies), epidemiology, injury prevention, bicycle safety, bicycle helmets, and various combinations of the above. These expressions, and similar terminology, were used to identify potential studies. The structure of the search procedures included subject, title, textword/keyword, along with some prominent author indexed searches. A bibliographic review of all articles was performed as each study was ascertained. Finally, advice and/or material was sought from various injury prevention and bicycle safety experts, the *Center for Disease Control, National Highway Traffic Safety Association, National Safety Council, 1990 Census Data located on the Internet,* and the *regional Think First Program.*

Studies Reviewed and Excluded

Eligible studies included those published in professional journals through the end of 1996. Therefore, this study was limited to published studies, due to the large number of studies uncovered through the search procedures, and the time limitations of the investigator. As a result, the present meta-analyses may include larger significant effects than if it had included unpublished effects, which is a recognized limitation of this study (Durlak 1995; Petitti 1994; Hedges & Olkin 1985; Glass 1981).

Following an initial review of the studies acquired from the various electronic databases, a decision was made to exclude all non-U.S.A. studies. This decision was based on five primary issues: 1.) insufficient knowledge regarding legal procedures and enforcement policies of legislative measures mandated in other countries, 2.) notable cost differences in medical care between various countries, 3.) the enormous literature available from United States researchers, 4.) the author's inability to comprehend their content and relevancy in relation to the questions being addressed, and 5.) funds were not available for costs associated with the translation of those not written in English.

As a result of the above decisions, 6 studies not written in English were excluded, leaving 102 international studies that were written in English. Eighty-two of the 102 (80%) had sufficient data for use in a meta-analysis. The regional composition of the 82 studies was as follows: Australia/New Zealand = 29, Canada = 16, United Kingdom (Ireland, Scotland, England) = 14, Scandinavia (Denmark, Sweden, Norway) = 9, Netherlands = 3, Finland = 4, Japan and Israel = 2 each, and one each from Russia, Nigeria, and Africa.

A total of 156 articles published by authors either reporting on or discussing bicycle-related injury, fatality, campaigns/programs or helmet usage in the United States were identified. These studies were further screened for suitability for meta-analysis. A total of 78 studies were excluded for the following reasons: 1.) articles did not provide any statistical or raw data; i.e., were principally review articles, commentaries, or theoretical papers (n=38), 2.) bicycle data was included, but was not sufficiently distinguished from data by other mechanisms (n=10), 3.) denominators were not provided for calculation of rate data (n=3), 4.) inability to extrapolate data with precision from tables where descriptive summary information was not provided, or did not conform to extrapolated data provided in tables (n=4), 5.) data provided was part of a subsequent study from the same facility over a longer time period (n=2), 6.) bicycle injury data related to child injury data resulting from bicycle-child safety seats (n=1), 7.) studies reported subjective estimates of either general safety or bicycle specific attitudes of parents and/or physicians (n=3), 8.) focus of the studies was on pedestrians, childhood injury, or brain injury in general, thereby lacking specific bicycle-related information (n=17). In addition, 8 studies were set aside as data was collected from professional or avid cyclists (members of cycling clubs or organizations), thereby not representing the recreational cyclist. Lastly, 1 study was eliminated because the author published an initial manuscript (the one eliminated) that reported general brain injury data by all mechanisms (including bicycling) from a regional database, and later published a manuscript detailing bicycle-related brain injuries from the same database, which covered the same time period (included study).

A total of 50 non-observational studies, and 21 observational/survey studies remained. Four of the 21 observational/survey studies were part 1/part 2 studies, making the total for this group of studies 19. Expectedly, the majority of non-observational/survey studies were retrospective studies reviewing bicycle-related injuries and mortalities. Thus, most non-interventional studies were single-case studies, or experimental designs that do not focus on between subjects data. Although these quasi-experimental designs are atypical of the studies commonly included in a meta-analytic procedure, they constitute the predominating design chosen by bicycle injury prevention researchers. Data extraction from these studies is intended to be abstracted and collated according to the outcome variables of interest, namely helmet usage, and ownership and purchase, in relation to mechanisms of injury, accident characteristics and experimental intervention, thereby enabling effect size estimates to be calculated. A list of the studies included in this analysis, distinguished by non-observational and observational/survey studies, is provided in Appendix A.

Synthesis Protocol

The coding record detailed various dimensions relevant to the questions under consideration including information pertaining to demographics, sample characteristics, methodological procedures, conceptual considerations, confounding factors, and outcome measures. All studies were coded solely by the author. When questions arose regarding the appropriate coding of any reported statistic, advice was sought from an un-biased statistician or meta-analysis researcher. Coding of these studies was according to investigator/statistician agreement, which represented 14% (n=10/71) of the studies. No cases of irreconcilable differences were encountered. Of the 10 studies, 7 reported subset data that altered either the actual reported proportions, or the calculation and subsequent direction of the effect size estimates (Westman et al. 1984; Selbst et al. 1987; Tucci & Barone 1988; Thompson et al. 1990; Belongia et al. 1991; Sacks et al. 1991; Gerberich et al. 1994). The remaining three cases involved 2 studies utilizing pre-post test designs with unequal sample sizes (Pendergrast et al. 1992; Schneider et al. 1993), and 1 study assessed data that modified the definition of head injury during the course of their study (Stutts et al. 1990).

Abstractor blinding was not performed, nor were multiple raters used. Lack of funds prevented implementation of measures to reduce these potential data collection biases from resulting. In an effort to improve the reliability of the investigator, the coding sheet was pilot tested on a sample of randomly chosen articles. Modifications in layout, clarification of item definitions, elimination of ambiguous terminology, assurance of missing and not appropriate information categories, and computerized notification of omitted responses to the associated database, were outcomes of the pilot testing of the data collection form. The protocol used to code the selected studies is provided in Appendix B. A Quality of Study Form was designed to objectively select the best quality study, when researchers or personnel from select institutions published manuscripts reporting duplicate data. This form was intended to be used when an obvious reason for reprinting the data was not apparent, i.e., longer study inclusion period, or more detailed bicycle-specific data was being presented. The Quality of Study Code Form is presented in Appendix C.

Multiple Publications from the Same Study Population

A few prominent injury prevention centers published serial studies using the same sample population. In an attempt to minimize the potential bias resulting from lack of independent estimates of an outcome measure, and related statistical violations of aggregate data that would result if multiple estimates of a measure were included from the same study population, only one estimate of a measure for each outcome was permitted for a given sample from serial publications from the same data set.

Multiple Measures from a Single Study

The preponderance of studies, 100% (n=50) of the non-observational studies and 42% (n=8) of the observational/survey studies provided data used in the estimation of only one outcome measure, namely helmet usage. However, 10.5% (n=2) of the observational/survey studies reported only helmet purchase information, while 37% (n=7) reported both helmet usage and helmet purchase information. Because some studies reported more than one outcome measure, it was decided a priori, that effect size estimates would be calculated for each outcome measure and suspected predictor variables in each study. Thus, if more than one outcome variable was present in a study, an effect size estimate would be calculated for each estimate, and each would be viewed as an independent estimate in the overall analysis. Although the incorporation of more than one effect estimate may result in the unintentional weighing of studies, the reason for this decision was due to the design of behavioral oriented injury prevention studies. It was found that these studies typically provided estimates reflecting a change from baseline for various types of interventions, or provided multiple estimates based on some classification. Therefore, while more than one estimate was not included for a specific intervention or potential predictor variable for each study in the overall analysis, multiple effect estimates were included from a given study if that study distinguished among various types of interventions or outcome measures in their design.

When data was sufficient to calculate several estimates for a given study, estimates adjusted for nationally recognized confounders (especially if they pertained to the author's primary or secondary hypotheses) were preferred over more general estimates of a measure. However, when multiple reports were available for estimation of any measure, the choice of which estimate to use was based on that which was easiest to work with. For example, given the choice between raw data or proportions and frequencies, raw data was selected, except when the majority of studies being reviewed only provided frequencies and proportions. Thus, if the largest percentage of studies reported frequencies and proportions, and not raw data, frequencies and proportions were used in the analysis. Moreover, when both frequencies and proportions were reported, frequencies were selected for entry, due to the higher level of accuracy of measurement.

Statistical Analysis

Effect Size Estimation

Effect size measurements were calculated for each study that provided sufficient data, based on the postulate being examined. Variables identified as important confounders included age, sex, race, socioeconomic status, highest educational level attained by parents or guardians, and types of injuries incurred by bicyclists. It was theorized that the benefit of helmet use was not thoroughly investigated with consideration given to all of these issues, although several states and counties passed legislation that would indirectly or directly effect all of these factors. Therefore, in an attempt to clarify the role bicycle helmets play in the prevention of bicycle-related injuries for all bicyclists, with an emphasis on head injuries, effort was given to the abstraction of this information from all studies reviewed. It was perceived that if such information was gathered and analyzed in various sub-groups of bicyclists, more definitive inferences could be made either for or against bicycle helmet mandates, imposed noncompliance fines, and limitations placed on all children whose families could not afford them.

Both parametric and non-parametric effect size statistics were anticipated to be used in this meta-analysis. However, the lack of uniformity in the presentation and categorization of the notable potential confounding factors, prevented most effect size estimates associated with the hypotheses of interest from being calculated. However, the few effect size estimates associated with the outcome(s) of interest that were possible, were computed using the proportions and frequencies sub-menu in the DSTAT meta-analysis program (Johnson 1989). Data from the coding sheets were first entered into SPSS and Quattro Pro databases created by the author to query the data. Studies with adequate data for effect size estimates, where subsequently entered into the DSTAT meta-analysis computer program. Each estimate was corrected for sample size bias. Accordingly, the corresponding effect size estimates were *d'*.

Effect Size Estimate Calculation

The formula used by the DSTAT meta-analysis software program to calculate *g'*, the effect size estimate not corrected for sample size for proportions and frequencies, is provided below. Each proportion is treated as the mean of the distribution of 0's and 1's (Johnson 1989). Thus,

$$g = \frac{(p_E - p_C)}{s_{pooled}}$$

where p_E and $_Cp$ represent proportions for the experimental and control groups, respectively, and "s_{pooled} is the pooled standard deviation of the samples of 0's and 1's", such that,

$$s_{pooled} = \left(\frac{[(n_E - 1) * s_E^2 + (n_C - 1) * s_E^2]}{[n_E + n_C - 2]}\right)^{1/2}$$

where n_E and n_C indicate the number of observations in the experimental and control groups, and s^2_E and s^2_C indicate the variances for the experimental and control groups, respectively (Johnson 1989, p. 105). The variance for each group, s^2, is calculated by the following formula:

$$s^2 = p * (1 - p),$$

where *p* represents the variance for the associated group. Each uncorrected effect size estimate, *g'*, was simultaneously corrected for sample size, producing *d'*. The resulting *d'* values were used for all statistical analyses. Note, Johnson (1989) recommends that frequencies be entered over proportions when possible, due to the potential for inaccuracy attributable to rounding error found in proportionate data. This recommendation was respected in the calculation of all effect size estimates, data permitting.

Analysis of Composite Effect Sizes

Proceeding the calculation of individual effect size estimates, only four composite effect size estimates were calculated for helmet usage. Once again, the reason for this was the lack of uniformity and inconsistency in the literature for the remaining outcomes of interest. The DSTAT meta-analysis computer program by Johnson (1989), incorporates a four step procedure in the analysis of effect size estimates. The initial step involves the calculation of a composite effect size. The program assigns the greatest weight to the studies with the most reliable estimated outcomes, namely, those studies with the largest sample sizes (Johnson 1989). Consideration is given to the "magnitude, directions, significance, and consistency of effect sizes in the data set," at this phase of the analysis (Johnson 1989, p. 20). A test of homogeneity, determination of whether the set of studies share a common effect size, can also be examined during this phase of analysis using DSTAT. Homogeneity of effect sizes was tested for each outcome. When heterogeneity was detected, indicating that the group of studies used to compose the mean weighted effect size do not all estimate the same parameter, outlier analysis was performed.

Model testing (step 2) and outlier analysis (step 3) are two optional components of the DSTAT program, recommended when heterogeneity of effect sizes is found (Hedges and Olkin 1985; Johnson 1989; Petitti 1994). Only the outlier analysis procedure was undertaken when heterogeneity was detected, due to the lack of uniform reporting of study qualities. Outlier effect sizes that were noted to influence the homogeneity of the composite effect size were sequentially removed according to those estimated to provide the greatest reduction in the homogeneity statistic. The substantial amount of heterogeneity found among these studies was illustrated by the number of effect sizes that had to be removed from a particular composite measure before homogeneity was maintained. Among observational studies, 2 of 8 effect sizes were required to be removed in order for the composite effect measure to comply with the assumption of homogeneity. However, of the remaining 6 entries, 3 referenced the same area, and thus were not completely independent.

The non-observational studies faired even poorer than did the observational studies in regards to homogeneity. In examination of helmet use among those injured and not injured, 13 of 15 effect size estimates would have had to be removed, leaving only two studies, for the homogeneity assumption to be met. In addition, 19 of 24 studies necessitated removal in the examination of bicycle-related injuries sustained as a result of a MVA versus Non-MVA bicycle accident.

The final step available, and recommended by the author of the DSTAT meta-analysis program, was the examination of the visual displays (Johnson 1989). Visual display analysis, such as the plotting of individual effect size estimates against predictors, is recommended to assist in the identification of outliers, and to enable the investigator to better interpret the overall results. Due to the substantial amount of heterogeneity noted, lack of uniformity in the data reported among the studies reviewed, and subsequently the insufficient number of quality studies for analysis, visual displays were not done for the modeled outcomes.

As appropriate, and data permitting, the effectiveness of various injury prevention program outcome measures will be assessed with ANOVA analogous procedures using effect size estimates. Regression analysis will be used to identify variables that explain significant variation in the effect size estimates for the outcome measures of interest.

Hypotheses

The primary aim of this study is to provide a description of the effect size estimates associated with bicycle related injuries and helmet usage patterns. These measures will be used to thoroughly, and objectively, evaluate this body of literature. However, the complexity and controversial nature of the issues surrounding bicycle helmets necessitated the formulation of various sub-classifications of hypotheses. Specifically, four distinct categories of hypotheses were conceived, namely, helmet related, injury related, bicycle safety campaigns/interventions, and significant confounding variables. In addition, a series of secondary and tertiary questions were posed in each category, that were deemed essential to a factual and reliable answer to one fundamental question, "Is compulsory bicycle helmet legislation warranted?" All secondary and tertiary questions listed in the sub-categories provided below, were believed to either directly or indirectly influence the following two primary questions:

1.) Have bicycle helmets been sufficiently evaluated in samples that are representative of the population of recreational cyclists, and thus the population at large, (i.e., in all races, among all age groups, in all socioeconomic classes, and among all individuals or families with varying educational backgrounds), to warrant mandatory helmet legislation for all cyclists, or just select members of our society?

2.) Has legislation been shown to be the most effective means of significantly increasing bicycle helmet usage, thereby indirectly reducing the number of bicycle-related injuries?

All supplementary hypotheses are presented below. Numbers with subscripts reflect affiliated tertiary hypotheses that will be addressed, data permitting.

<u>Helmet Related Hypotheses</u>

1. Bicycle safety interventions, regardless of type of intervention, will consistently show an increase in helmet usage.

    1a. Multi-faceted bicycle safety interventions, i.e., those involving more than one approach (program/intervention) will show greater effects than interventions utilizing less comprehensive approaches (single interventions), in relation to increased helmet usage.

2. Prospective studies measuring the effectiveness of bicycle safety programs/interventions will show larger bicycle helmet usage effects than studies whose primary aim was to evaluate bicycle related injuries.

3. Bicycle safety interventions, regardless of type of intervention, will consistently show a greater increase in helmet usage patterns among individuals less than 16 years, versus children greater than or equal to 16 years.

4. Helmet usage will be more prevalent among females, and families with children from white, middle and upper-middle classes.

<u>Injury Related Hypotheses</u>

1. Studies which focus on bicycle related head injuries and bicycle related fatality data, will reveal larger injury effect estimates than studies reporting all bicycle related injury data.

    1a. Studies focusing on bicycle related injuries, especially bicycle related brain injuries, will reveal smaller effect size estimates for helmet wearers versus non-helmet wearers, thereby overstating the preventative effect of helmets in the general bicycling population.

1b. Hospital and fatality data will reveal larger effect size estimates for helmeted and non-helmeted bicyclists sustaining neurologic injuries versus other types of injuries; thereby suggesting a greater prevalence of neurological injuries (and their association with non-helmeted cyclists) in the general population of bicyclists.

1c. No reduction in the number of bicycle related brain injuries over the past decade will be found, as evident by similar effect size estimates, rather than decreasing effect size estimates as the studies become more recent.

2. Larger effect size estimates for children less than 16 years versus those greater than or equal to 16 years will be found for bicycling accidents reportedly due to bicyclist error (as compared to motorist error); thereby suggesting that children are more likely than adults to be responsible for their bicycling accidents.

3. Bicycle-motor vehicle collisions will reveal larger effect size estimates than other types of accidents (falls, pedestrian versus bicyclist, etc.) when examined in relation to all types of bicycle injuries, and even more so in relation to bicycle related brain injuries.

4. Larger effect size estimates will be found for males, in both children (< 16 years) and in adults ($\geq$ 16 years) in relation to all types of bicycle related injuries.

5. Orthopedic injuries will reveal larger effect size estimates than both neurologic and "other" (all other types of injuries) injury classification of bicycle related injuries, for all bicyclists.

Bicycle Safety Campaign/Intervention Hypothesis

1. Larger effect size estimates will be found for whites and middle and upper middle class families, compared to minorities and lower income and impoverished individuals. Should such a pattern correspond with low minority representation in selected sample populations for program evaluation, it will lend crecidence to this author's belief that reported results are not representative of the population at large. A finding that may be even more prevalent among the campaigns reporting the highest success rates.

Significant Confounding Variables Hypothesis

1. Aside from the above mentioned factors (race, gender, age, cause of accident, and type of accident) location of accident, time of day of accident, season of accident, and region of the country will all be shown to contribute significantly to helmet usage and the type of injuries sustained by bicyclists.

CHAPTER 4

RESULTS

The topic of investigation, whether or not bicycle helmets have been shown to be efficacious in the prevention of bicycle-related injuries, with an emphasis on head injuries, among all members of our society, was broadly defined to include all studies pertaining to bicycle-related injuries, helmet usage or helmet purchase. It was perceived that this would yield a large selection of studies that were fundamental to the primary question of interest, namely, "Is there sufficient evidence to conclude that bicycle helmet legislation is justified?" Rather than preselecting a subset of studies based on some quality criteria to encompass the meta-analytic review, all relevant studies providing some data on the outcomes of interest were assessed for important explanatory variables of interest (age, gender, race, socioeconomic status, highest level of education attained by a parent or guardian, and type of injury sustained). Table 1 presents a summary of important characteristics of the studies included in this meta-analysis. Studies are separated into two categories due to the distinct characteristics associated with the designs: non-observational studies - data acquired from hospitals, surveillance systems, medical examiners, police reports, etc., and observational/survey studies. The format for this summary table was patterned after that reported by Mark Lipsey (1992, pp. 101-112). The bibliographic citations of the included studies are presented in Appendix C.

Table 1: Descriptive Summary of Primary Study Variables

NON-OBSERVATIONAL/SURVEY STUDIES (N=50)

General Study Information

	N	%
Year of Publication:		
1970-1974	0	0
1975-1979	3	6
1980-1984	8	16
1985-1989	11	22
1990-1994	16	32
1995-1996	12	24
Missing	0	0
Primary Author's Education		
M.D.	31	62
Ph.D.	9	18
M.S.	2	4
R.N.	0	0
Other	3	6
Missing	5	10

	N	%
Type of Journal/Publication		
Medical	39	78
Educational	0	0
Safety	6	12
Allied Health	0	0
Public Health	5	10
Scientific	0	0
Other	0	0
Affiliation of Primary Author		
1° Injury Prevention Center	7	14
Hospital Only	2	4
Trauma Center	2	4
Academic/Teaching Institution	28	56
Governmental Agency	11	22
Other	0	0

Study Characteristics

	N	%
Location of Study		
NE	10	20
SE	7	14
MW	11	22
SW	4	8
W	12	24
Nationwide	6	12
Type of Data		
Hospital Data	15	30
Mortality Only Data	6	12
National Surveillance System (NEISS,	5	10

	N	%
Type of Study		
Retrospective	33	66
Prospective	7	14
Cohort	1	2
Case-Control	0	0
Retrospective w/ subset survey	6	12
Prospective w/ subset survey	2	4
Cohort w/ subset survey	0	0
Case-Control w/ subset survey	1	2

	N	%
NHTSA, CDC, National Registry, etc.)		
Regional Surveillance System	15	30
Combination of Data	9	18

Subject Characteristics

Age Categories	N	%
Children Only (range within 0-19 years)	16	32
Adults Only (≥ 20 years)	3	6
Both children and Adults	31	62
Not specified	0	0

Ethnicity	N	%
Bicyclist specific	5	10
All subjects	2	4
Limited	1	2
Not Specified	42	84

Predominate Ethnicity of Subjects	N	%
Caucasian/White	6	12
Black	1	2
Hispanic	0	0
Other Minority	1	2
Mixed, none > 50%	0	0
Mixed, can't estimate	0	0
Not Provided	42	84

Reports SES of Primary Household Member	N	%
Bicyclist specific	3	6
All Subjects	4	8
Not Provided	43	86

Reports Highest Attained Level of Education of 1° Household Member	N	%
Bicyclist specific	1	2
All subjects	1	2
Not Specified	48	96

Gender	N	%
Bicyclist specific	23	46
All subjects	3	6
Rate data w/o Denom.	4	8
Provisionally provided (abstraction difficult)	7	14
Not provided	13	26

Methodology

Sample Size	N	%
1-25	8	16
26-50	2	4
51-75	1	2
76-100	3	6

Studies w/ Group Assignment	N	%
Yes	6	12
No	44	88
Unknown	0	0

	N	%
101-150	3	6
151-200	5	10
201-300	9	18
301+	19	38

Method of Group Assignment (if applicable)	N	%
Random (no matching)	0	0
Random after matching	0	0
Non-random (matched on injury or surveillance system)	5	10
Non-random (matched on demographics)	0	0
Non-random (matched on 'other' or substudies)	1	2
Convenience Comparison	0	0
Not applicable (no group assignment)	44	88

Researcher's Comparison of Helmeted/Non-helmeted Cyclists	N	%
Provided but no comparisons	3	6
Descriptive Only	5	10
Significance Tests	7	14
Not able	35	70
(no hel. info)	*31*	*89*
(noone wearing helmet)	*4*	*11*

Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Gender	N	%
Yes	3	6
Helmet info., but not reported for gender	9	18
No helmet info., but gender info.	15	30
Not able	23	46
(noone wearing helmet)	*4*	*17*
(no helmet or gender info.)	*17*	*74*
(rate data w/o denom. & no helmet info.)	*2*	*9*

Direction of Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Gender. Helmet use:	N	%
Favors Males	0	0
Favors Females	2	4
Favors Neither	1	2
Not Reported	45	90
Not able	2	4
(noone wearing helmet)	*2*	*100*

Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Race	N	%
Yes	0	0
Helmet info., but not reported for race	0	0
No helmet info., but race info.	5	10
Not able	45	90
(Race not reported)	*15*	*33*
(noone wearing helmet)	*1*	*2*
(no helmet or race info.)	*28*	*62*
(limited race info., & no helmet info.)	*1*	*2*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Race. Helmet use:	N	%
Favors Whites	0	0
Favors Nonwhites	0	0
Favors Neither	0	0
Not Reported	49	98
Not able	1	2
(noone wearing helmet)	*1*	*100*

Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Age Groups		
Yes	5	10
Helmet info., but not reported by age	5	10
No helmet info., but age info.	21	42
Not able	19	38
(Helmet info., but selective ages)	*4*	*21*
(noone wearing helmet)	*4*	*21*
(no helmet or age group info.)	*10*	*53*
(limited age info., w/ tabled %'s)	*1*	*5*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Age Groups. Helmet use:		
Favors < 20 years	0	0
Favors ≥ 20 years	5	10
Favors Neither	0	0
Not Reported	28	56
Not Able	17	34
(only children)	*15*	*88*
(only adults)	*2*	*12*

Researcher's Comparison of Helmeted/Non-Helmeted Cyclists by SES of 1° Household Member		
Yes	0	0
Helmet info., but not reported by SES	1	2
No helmet info., but	1	2

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by SES of 1° Household Members. Helmet use:		
Favors Middle-Upper Middle Income	0	0
Favors Low Income	0	0

	N	%
SES info.		
Not able	48	96
(SES not reported)	*13*	*27*
(noone wearing helmet but SES info.)	*1*	*2*
(no helmet or SES info.)	*34*	*71*

	N	%
Favors Neither	0	0
Not Reported	49	98
Not able	1	2
(noone wearing helmet but SES info.)	*1*	*100*

Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Highest Education of 1° Household Member

	N	%
Yes	0	0
Helmet info., but not reported by Education	1	2
No helmet info., but Education info.	1	2
Not able	48	96
(Education not reported)	*13*	*27*
(noone wearing helmet but Education info.)	*0*	*0*
(no helmet or Education info.)	*35*	*73*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Highest Level of Education of 1° Household Member. Helmet Use:

	N	%
Favors Some College and more	0	0
Favors No College and Less	0	0
Not Neither	0	0
Not Reported	50	100
Not able	0	0
(noone wearing helmet but education info.)	*0*	*0*

Researcher's Comparison of Helmeted/Non-Helmeted Cyclists by Head Injury

	N	%
Yes	11	22
Helmet info., but not reported for head injury	4	8
No helmet info., but head injury info.	18	36
Not able	17	34
(noone wearing helmet but head injury info.)	*4*	*24*
(no helmet or head injury info.)	*13*	*76*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Head Injury. Helmet Use:

	N	%
Favors Head Injured	0	0
Favors Non-Head Inj. (or mild head inj.)	9	18
Favors Neither	2	4
Not Reported	38	76
Not able	1	2
(noone wearing helmet but head injury info.)	*1*	*100*

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Ortho. Injuries		
Yes	1	2
Helmet info., but not reported for ortho. injuries	11	22
No helmet info., but ortho. injury info.	11	22
Not able	27	54
(Ortho. injuries not reported)	*3*	*11*
(noone wearing helmet but ortho. injury info.)	*4*	*15*
(no helmet or ortho. injury info.)	*18*	*67*
(info. combined w/ inj. by another mechanism)	*2*	*7*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Ortho injury. Helmet Use:		
Favors Orthopedic Injuries	0	0
Favors Non-Orthopedic Injuries	1	2
Favors Neither	0	0
Not Reported	49	98
Not able	0	0
(noone wearing helmet but ortho. injury info.)	*0*	*0*

	N	%
Researcher's Comparison of Helmeted/Non-Helmeted Cyclists for 'Other' injuries		
Yes	2	4
Helmet info., but not reported for 'other' injuries	7	14
No helmet info., but 'other' injury info.	11	22
Not able	30	60
(Other injuries not reported)	*4*	*13*
(noone wearing helmet but 'other' injury info.)	*4*	*13*
(no helmet or other injury info.)	*22*	*73*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists for 'Other' injury. Helmet Use:		
Favors 'Other' Injuries	0	0
Favors 'Non-Other' Injuries	1	2
Favors Neither	1	2
Not Reported	46	92
Not able	2	4
(noone wearing helmet but 'other' injury info.)	*2*	*100*

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists for All Injuries		
Yes	1	2
Helmet info., but not reported for all injury types	7	14
No helmet info., but all injury info.	12	24
Not able	30	60
(All types of inj. not reported)	*5*	*17*
(noone wearing helmet but all inj. types info.)	*4*	*13*
(no helmet or inj. by all mechanisms info)	*17*	*57*
(info. combined w/ inj. by another mechanism)	*4*	*13*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists for All types of injury. Helmet Use:		
Favors any injury type or more severe	0	0
Favors Non-injured or less severe	1	2
Not Neither	0	0
Not Reported	47	94
Not able	2	4
(noone wearing helmet but all inj. types info.)	*2*	*100*

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Mortality		
Yes	6	12
Helmet info., but not reported for mortalities	1	2
No helmet info., but mortality info.	14	28
Not able	29	58
(No mortalities)	*8*	*28*
(noone wearing helmet)	*3*	*10*
(no helmet or mortality)	*18*	*62*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Mortality. Mortality:		
Favors Helmeted	0	0
Favors Non-helmeted	5	10
Favors Neither	0	0
Not Reported	10	20
Not able	35	70
(Only mortalities reported)	*7*	*20*
(No mortalities)	*8*	*23*
(noone wearing helmet)	*1*	*3*
(no helmet or mortality)	*19*	*54*

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists by MVA/Non-MVA Accidents		
Yes	1	2
Helmet info., but not	10	20

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by MVA/Non-MVA Accidents. Helmet Use:		
Favors MVA Collision	0	0

	N	%
reported for mortalities		
No helmet info., but mortality info.	13	26
Not able	26	52
(noone wearing helmet)	*4*	*15*
(no helmet or MVA/ Non-MVA info.)	*12*	*46*
(MVA Accidents Only)	*7*	*27*
(type of accident not reported or limited)	*3*	*12*

	N	%
Favors Non-MVA Collision	0	0
Favors Neither	1	2
Not Reported	40	80
Not able	9	18
(noone wearing helmet)	*2*	*22*
(MVA Accidents Only)	*7*	*78*

Researcher's Interpretation of Effect of Helmets in Prevention of Head Injuries	N	%
Beneficial	25	50
Not Beneficial	0	0
Mixed	0	0
No Conclusion	7	14
Not Discussed	18	36

Researcher's Interpretation of Effect of Protective Gear/ Safety Measure in the Prevention of Injuries in General	N	%
Beneficial	28	56
Not Beneficial	0	0
Mixed	0	0
No Conclusion	3	6
Not Discussed	19	38

Types of Statistics Used by Researcher for Helmeted/ Non-Helmeted Head Injury Comparisons	N	%
Descriptive Only	6	12
t, F, or z	0	0
Chi-square	3	6
Nonparametric	0	0
Other	1	2
Missing	1	2
None Done	39	78

Types of Statistics Used by Researchers for All Other Helmeted/Non-Helmeted Comparisons	N	%
Descriptive Only	1	2
t, F, or z	0	0
Chi-Square	3	6
Non-parametric	0	0
Other	0	0
Missing	0	0
None Done	46	92

	N	%
Researcher's Determination that Helmets were Beneficial without analyzing Helmet versus Non-helmet Injury Data in their study.		
Yes	13	26
No	25	50
Used Statistical Analysis	4	8
Descriptive Analysis Only	6	12
Reported Data found no difference by helmet usage	2	4

<u>Accident Information</u>

	N	%		N	%
Type of Accident (Falls, Contact w/ Stat. Object, Contact w/ MVA, Contact w/Oth Mov.Obj)			Cause of Accident (Environ., Poor Road Cond., Bike Error, Motorist Error, Bike Malf.)		
Provided	17	34	Provided	9	19
Partial/Limited	11	22	Partial/Limited	5	10
Not Provided	14	28	Not Provided	34	71
MVA only accid.	8	16			
Season of Accident			Time of Day of Accident		
Provided	7	14	Provided	5	10
Partial/Limited	3	6	Partial/Limited	8	17
Not Provided	40	80	Not Provided	35	73
Location of Accident (mj. roadway, bike path, neighborhood)					
Provided	3	6			
Partial/Limited	10	20			
Not Provided	37	74			

Researcher's Comparison of Helmeted/Non-Helmeted Cyclists by Time of Day of Accident (Daylight versus Darkness).	N	%
Yes	0	0
Helmet info., but not reported by time of day	6	12
No helmet info., but time of day info.	6	12
Not Reported	0	0
Not able	38	76
(Time of day of accident not reported)	*9*	*24*
(noone wearing helmet)	*3*	*8*
(no helmet or time of day info.)	*26*	*68*

Direction of Researcher's Comparison of Helmeted/ Non-Helmeted Cyclists by Time of Day of Accident (Daylight versus Darkness).	N	%
Helmet Use:		
Favors Daytime Cycling	0	0
Favors Nighttime Cycling	0	0
Favors Neither	0	0
Not Reported	6	12
Not able	44	88
(noone wearing helmet	*3*	*7*
(Time of day of accident not reported)	*9*	*20*
(no helmet or time of day info.)	*26*	*59*
(no helmet info.)	*6*	*14*

OBSERVATIONAL/SURVEY STUDIES (N=21 with 2 sets of Part 1/Part 2 studies)

General Study Information

	N	%		N	%
Year of Publication:			Type of Journal/Publication		
1970-1974	1	5	Medical	12	57
1975-1979	1	5	Educational	0	0
1980-1984	0	0	Safety	2	10
1985-1989	3	14	Allied Health	3	14
1990-1994	13	62	Public Health	4	19
1995-1996	3	14	Scientific	0	0
Missing	0	0	Other	0	0

	N	%		N	%
Primary Author's Education			Affiliation of Primary Author		
M.D.	15	72	1° Injury Prevention Center	3	14
Ph.D.	3	14	Hospital Only	0	0
M.S.	0	0	Trauma Center	0	0
R.N.	0	0	Academic/Teaching Institution	14	67
Other	3	14	Governmental Agency	4	19
Missing	0	0	Other	0	0

Study Characteristics (N=19 counting Part 1/Part 2 studies as one study)

	N	%		N	%
Location of Study			Type of Study		
NE	7	37	Observational Only	7	37
SE	2	10.5	Observational w/ Quest/Survey	1	5
MW	2	10.5	Observational w/ Interview	0	0
SW	2	10.5	Quest/Survey Only	6	32
W	4	21	Quest/Survey w/ Interview	3	16
Nationwide	2	10.5	Interview Only	2	10
			(Part 1/Part 2 Studies	*2)*	*100*

	N	%
Studies w/ Pre-Post Test Design		
Quest/Survey	3	16
Observational	4	21
Combined	1	5
Not Applicable	11	58
(references results of earlier publication)	*1*	*100*

<u>Subject Characteristics</u>

	N	%
Age Categories		
Children Only (range within 0-19 years)	10	53
Adults Only (≥ 20 years)	3	16
Both children and Adults	5	26
Categories w/o specific ages	1	5
Not specified	0	0
Ethnicity		
Bicyclist specific	7	37
All subjects	0	0
General Community information	3	16
Not Specified	9	47
Predominate Ethnicity of Subjects		
Caucasian/White	9	47.5
Black	0	0
Hispanic	0	0
Other Minority, or just minorities	1	5
Mixed, none > 50%	0	0
Mixed, can't estimate	0	0
Not Provided	9	47.5

	N	%
Reports SES of Primary Household Member		
Bicyclist specific	4	21
All Subjects	6	32
Not Provided	9	47
Reports Highest Attained Level of Education of 1° Household Member		
Bicyclist specific	5	26
All subjects	0	0
General Community information	1	5
Not Specified	13	69
Gender		
Bicyclist specific	14	74
All subjects	0	0
Not Specified	5	26

Methodology

	N	%
Sample Size		
1-25	0	0
26-50	0	0
51-75	0	0
76-100	1	5
101-150	0	0
151-200	0	0
201-300	1	5
301+	17	90
Sample Size in Pre-Post Test Quest/Survey Design		
Equivalent	0	0
More Pretest	2	10
More Posttest	0	0
Not Reported	0	0
Not Applicable	17	90
Sample Size in Pre-Post Test Observational Design		
Equivalent	0	0
More Pretest	3	16
More Posttest	1	5
Not Reported	0	0
Not Applicable	15	79
Type of Intervention(s) Being Evaluated		
Legislative Only	0	0
Educational Only	2	10
Community Only	0	0
Legis. + Educ.	0	0
Legis. + Comm.	0	0
Educ. + Comm.	6	32
All three	4	21
No Specific Campaign	7	37

	N	%
Studies w/ Group Assignment		
Yes	8	42
No	11	58
Unknown	0	0
Number of Experimental Groups or Sampled Samples		
One	11	58
Two	3	16
Three	3	16
Four	2	10
Five or More	0	0
Not Reported	0	0
Months Between Pre-Post Test Surveys or Observations		
< 1 month	0	0
1-3 months	0	0
4-6 months	1	5
7-12 months	3	16
13-24 months	1	5
> 24 months	2	11
Not Reported	0	0
Not Applicable	12	63
Researcher's Method of Comparison of Helmeted/ Non-Helmeted Cyclists		
Self-Report-Kids	2	10.5
Self-Report-Adults	1	5
Self-Report-Both	4	21
Interview-Kid	0	0
Interview-Adult	0	0
Interview-Both	2	10.5
Combination of Self-	2	10.5

	N	%
(Helmet Attitudes/ Usage)	*4*	*57*
(Bicycle Use)	*2*	*29*
(Bicycle Safety/ Road Rules)	*1*	*14*

	N	%
Report & Interview Observation Only	7	37
Observation & Questionnaire	1	5

Researcher's Comparison of Helmeted/Nonhelmeted Cyclists	N	%
No Comparison	0	0
Descriptive Only	5	26
Significance Tests	12	63
Not Provided	2	11
Not Able (no hel. info)	0	0

Primary Outcome Measure	N	%
Helmet Usage	8	42
Helmet Purchase	2	10.5
Both	7	37
Neither, Other	2	10.5

Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Gender	N	%
Yes	9	47
Helmet info., but not reported for gender	3	16
No helmet info., but gender info.	2	11
Not able	5	26
(Gender not reported)	*5*	*100*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Gender. Helmet Use:	N	%
Favors Males	3	16
Favors Females	2	10
Favors Neither	4	21
Not Reported	10	53

Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Race	N	%
Yes	6	32
Helmet info., but not reported for race	1	5
No helmet info., but race info.	0	0
Not able	12	63
(Race not reported)	*8*	*67*
(no helmet or race) info.)	*1*	*8*
(General community info. only)	*3*	*25*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Race	N	%
Favors Whites	5	26
Favors Nonwhites	0	0
Favors Neither	1	5
Not Reported	13	69

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Age Groups		
Yes	8	42
Helmet info., but not reported by age	1	5
No helmet info., but age info.	1	5
Not able	9	48
(limited age group info.)	*9*	*100*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Age Groups		
Favors < 20 years	1	5
Favors ≥ 20 years	4	21
Favors Neither	0	0
Not Reported	2	11
Not able	12	63
(only adults reported)	*2*	*17*
(only kids reported)	*7*	*58*
* *(favors younger kids)*	*2*	*17*
* *(favors older kids)*	*1*	*8*

	N	%
Researcher's Comparison of Helmeted/Non-Helmeted Cyclists by SES of 1° Household Member		
Yes	9	47.5
Helmet info., but not reported by SES	1	5
No helmet info., but SES info.	0	0
Not able	9	47.5
(no helmet or SES info.)	*1*	*11*
(limited, general community info.)	*3*	*33*
(SES not reported)	*5*	*56*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by SES of 1° Household Mem.		
Favors Middle & Upper Incomes	3	16
Favors Lower Incomes	0	0
Favors Neither	2	10
Not Reported	10	53
Only Middle-Upper Middle Incomes included in study	4	21

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Highest Education of 1° Household Member		
Yes	5	26
Helmet info., but not reported by Education	2	11
No helmet info., but Education info.	0	0
Not able	12	63

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Highest Education of 1° Household Member		
Favors Some College and More	4	21
Favors No College and Less	0	0
Not Neither	0	0
Not Reported	15	79

	N	%
(Education not reported)	*11*	*92*
(limited, general community info.)	*1*	*8*

	N	%
Researcher's Comparison of Helmeted/Non-Helmeted Cyclists by Head Injury		
Yes	2	11
Helmet info., but not reported for head injury	0	0
No helmet info., but head injury info.	1	5
Not able	16	84
(head injury not reported)	*16*	*100*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Head Injury. Helmet Use:		
Favors Head Injured	0	0
Favors Non-head Inj.	3	16
Favors Neither	0	0
Not Reported	16	84

	N	%
Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Ortho. Injuries		
Yes	0	0
Helmet info., but not reported for ortho. injuries	0	0
No helmet info., but ortho. injury info.	1	5
Not able	18	95
(ortho. injuries not reported)	*18*	*100*

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists by Orth. Injuries. Helmet Use:		
Favors Ortho. Inj.	0	0
Favors Non-ortho.	0	0
Favors Neither	0	0
Not Reported	19	100

	N	%
Researcher's Comparison of Helmeted/Non-Helmeted Cyclists for 'Other' injuries		
Yes	1	5
(listed as non-head)	*1*	*100*
Helmet info., but not reported for 'other' injuries	0	0
No helmet info., but 'other' injury info.	1	5

	N	%
Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists for Other injuries. Helmet Use:		
Favors 'Other' Inj.	0	0
Favors Non-Other Inj	1	5
Favors Neither	0	0
Not Reported	18	95

	N	%
Not able	17	90
('other' injuries not reported)	*17*	*100*

Researcher's Comparison of Helmeted/Non-helmeted Cyclists for All Injuries

	N	%
Yes	2	11
Helmet info., but not reported for all injury types	0	0
No helmet info., but all injury info.	0	0
Not able	17	89
(all injuries not reported)	*17*	*100*

Direction of Researcher's Comparison of Helmeted/ Non-helmeted Cyclists for All Injuries. Helmet Use:

	N	%
Favors Any Inj. Type	0	0
Favors Non-Injured	2	11
Favors Neither	0	0
Not Reported	17	89

Researcher's Interpretation of Effect of Helmets in Prevention of Head Injuries

	N	%
Beneficial	16	84
Not Beneficial	0	0
Mixed	0	0
No Conclusion	2	11
Not Discussed	1	5

Researcher's Interpretation of Effect of Protective Gear/ Safety Measures in the Prevention of Injuries in General

	N	%
Beneficial	7	37
Not Beneficial	1	5
Mixed	0	0
Not Conclusion	0	0
Not Discussed	11	58

Types of Statistics Used by Researcher for Helmeted/ Non-Helmeted Head Injury Comparisons

	N	%
Descriptive Only	1	5
t, F, or z	0	0
Chi-square	0	0
Nonparametric	0	0
Other	2	11
Missing	0	0
None Done	16	84

Types of Statistics Used by Researchers for All Other Helmeted/Non-Helmeted Comparisons

	N	%
Descriptive Only	2	10
t, F, or z	0	0
Chi-Square	3	16
Non-parametric	0	0
Other	3	16
Missing	1	5
None Done	10	53

	N	%
Researcher's Determination that Helmets were Beneficial without analyzing Helmet versus Non-helmet Injury Data in their study		
Yes	13	68
No	3	16
Used Statistical Analysis	3	16
Descriptive Analysis Only	0	0

<u>Accident Information</u>

	N	%		N	%
Type of Accident (Falls, Contact w/ Stat. Object, Contact w/ MVA, Contact w/Oth Mov.Obj)			Cause of Accident (Environ., Poor Road Cond., Bike Error, Motorist Error, Bike Malf.)		
Provided	0	0	Provided	1	5
Partial/Limited	1	5	Partial/Limited	0	0
Not Provided	18	95	Not Provided	18	95
Season of Accident			Time of Day of Accident		
Provided	0	0	Provided	0	0
Partial/Limited	0	0	Partial/Limited	2	11
Not Provided	19	100	Not Provided	17	89
Location of Accident (mj. roadway, bike path, neighborhood)					
Provided	0	0			
Partial/Limited	1	5			
Not Provided	18	95			

Observation/Survey Information

	N	%
Helmet Usage by Observational Site (roadway, residential street, parks/bike paths)		
Provided	5	26
Partial/Limited	0	0
Not Provided	6	32
Survey Only	8	42
Researcher's Comparison of Helmet/Non-Helmeted Cyclists by Time of Day of Observation (Daylight versus Darkness)		
Yes	0	0
Helmet info., but not reported by time of day of observation	0	0
No Helmet info., but time of day of observation info.	2	11
Not able	17	89
(time of day of observation not reported)	*8*	*47*
(only daytime observation/interviews)	*9*	*53*
Researcher Surveyed or Interviewed Subjects regarding Reasons for Not Wearing or Owning a Bicycle Helmet		
Yes	6	32
No	13	68

	N	%
Direction of Researcher's Comparison of Helmeted/Non-helmeted Cyclists by Observation Site/Survey Results. Helmet Use:		
Favors Residential area	0	0
Favors Roadways	2	11
Favors Parks/Bike Paths	2	11
Favors None	2	11
Not Reported	13	68
Direction of Researcher's Comparison of Helmeted/Non-Helmeted Cyclists by Time of Day of Observation (Daylight versus Darkness). Helmet Use:		
Favors Daylight	0	0
Favors Darkness	0	0
Favors Neither	0	0
Not Reported	10	53
Not able	9	47
(only daytime observation/interviews)	*9*	*100*
Leading Reason Reported for Not Purchasing a Bicycle Helmet		
Cost	1	5
Appearance	0	0
Comfort	1	5
Didn't Think About It	2	11
Other	0	0
Not Reported	15	79

	N	%
Leading Reason Reported for Not Wearing a Bicycle Helmet		
Comfort	1	5
Not Riding in Traffic	1	5
Riding a Short Distance	3	16
Appearance	0	0
Not Necessary	0	0
Didn't Think About It	1	5
Not Reported	13	69

<u>Pre to Post Intervention Evaluation</u>

	N	%
Helmet Use/Purchase Pre to Post Intervention or Test Measured		
Yes	10	53
No	0	0
Not Applicable	9	47

	N	%
Helmet Purchase Pre to Post Intervention reported as:		
Increasing	2	10.5
Significantly	*0*	*0*
Significance not provided	*2*	*100*
Decreasing	2	10.5
Significantly	*0*	*0*
Significance not provided	*2*	*100*
No Difference Significance or otherwise	1	5
Mixed Findings	0	0
Not Reported	0	0
Not Applicable	14	74

	N	%
Primary Type of Helmet Observed or Reported Using		
Hard Shell	3	16
Soft Shell	0	0
Leather	0	0
Unknown	0	0
Not Reported	16	84

	N	%
Helmet Use Pre to Post Intervention reported as:		
Increasing	8	42
Significantly	*6*	*75*
Significance not provided	*2*	*25*
Decreasing	0	0
Significantly	*0*	*0*
Significance not provided	*0*	*0*
No Difference Significantly or otherwise	0	0
Mixed Findings	1	5
Not Reported	0	0
Not Applicable	10	53

	N	%
Intention to Use a Helmet Pre to Post Intervention Based on Reported Findings		
Increased Helmet Usage	7	37
Significantly	*5*	*71*
Significance not provided	*2*	*29*
Decreased Helmet Usage	0	0
Significantly	*0*	*0*
Significance not provided	*0*	*0*
No Difference Significantly or otherwise	1	5
Mixed Findings	1	5
Not Reported	0	0
Not Applicable	10	53
Researcher's Comparison of Various Types of Interventions Found the Following to be Best		
Legislation Only	3	16
Education Only	0	0
Community Only	0	0
Legislation & Education	1	5
Legislation & Community	0	0
Education & Community	0	0
Only evaluated one type of intervention	7	37
(education - no improvement)	*1*	*14*
(community - mixed finding)	*1*	*14*
(Educ. & Comm. -	*5*	*72*

(all 3 based on same regional campaign)

	N	%
Intervention Shown to be Effective Based on Reported Findings (either helmet usage or purchase)		
Increased Helmet Usage/Purchase	9	47
Significantly	*5*	*56*
Significance not provided	*4*	*44*
Decreased Helmet Usage/Purchase	0	0
Significantly	*0*	*0*
Significance not provided	*0*	*0*
No Difference Significantly or otherwise	1	5
Mixed Findings	2	11
Not Reported	0	0
Not Applicable	7	37
No intervention Implementation, but helmet usage assessed (via survey mostly)	*5*	*71*

	N	%		N	%
beneficial)					
No Direct Intervention Implemented, but Improvement shown	1	5			
Not Applicable	7	37			
No intervention implemented, but helmet usage assessed (via survey mostly)	*5*	*71*			

Explanation of Definitions

Bicycle related head injury studies were defined as studies (or entries) that focused on head injuries sustained by cyclists (or by all mechanisms, with a distinction given to cyclists) in their stated purpose, hypotheses, or sample composition. Only one of the five studies included in this category for evaluation of helmet usage by type of injury, and subsequently by accident type, had a subject population that was not exclusively head injured bicyclists. This study was comprised of 54% bicycle-related head injury subjects, and the authors aimed to evaluate the characteristics and outcomes of head injury incurred by cyclists (Li et al. 1995). In contrast to the head injury group, the general bicycle related injury group included all studies (or entries) that aimed to evaluate bicycle-related injuries in general, or included bicycle-related injuries in their more global assessment of injuries by other mechanisms. As such, head injured bicyclists were included in this category, but no entry contained greater than 35% (range = 13.3% to 35%). Moreover, the majority of these studies classified head and neck injuries as one category without distinguishing between the two types of injuries, and registered more than the primary injury in their report of the number (or proportion) of injuries sustained. Thus, injuries typically added to greater than 100%.

However, because the goal of this manuscript was to thoroughly evaluate all reported bicycle related injuries among recreational cyclists, an attempt was made to obtain an exhaustive sample of the studies providing information on bicycle related injuries. This led to the acquisition of studies that aimed to report pediatric injury in its entirety, while providing data exclusive to bicyclists, as well as those that sought to evaluate the outcome of bicycle-related injuries in general. The reason for this was the perceived bias in the studies whose primary goal was examination of bicycle-related injuries for the sole purpose of demonstrating the need for bicycle helmets, or the success of an implemented campaign to promote bicycle helmet usage. This author felt that approaching the selection of studies in this manner would allow for the acquisition of studies that both examined the hypotheses of interest to the author, as well as provided an impartial assessment of the bicycle-related helmet literature.

Therefore, although entries were classified as general, fatality, head-focused, observational, and survey (initially with various sub-categorizations), some overlap occurred. The most common overlap occurred with some studies having greater than 50% head injured subjects that were not classified as head injury entries. Studies examining bicycle-related fatalities typically reported greater than 50% head injuries. However, this author believe that classifying these entries as head entries would have artificially inflated the number of bicycle-related head injuries (and effect size estimate) sustained by the general population of cyclists. In addition, two studies classified as "general" studies also reported greater than 50% head injuries - Nakayama et al. (1990), and King et al. (1991) who reported 69% and 68%, respectively. However, the purpose of Nakayama and associates (1990) study was to provide information on examine the impact of long-term disability on victims of bicycle-related accidents. Therefore, similar to fatality victims, those bicyclists incurring an injury that required long-term care, are more likely to sustain a head injury than other forms of injury. However, inclusion of this study in with the head injury group, whose constituent entries specifically aimed to evaluate head injuries, was felt would have misrepresented the bicycle-related head injuries. Similarly, King and colleagues' (1991) study was also excluded from the head injury group because the primary aim of this study was to evaluate the effectiveness of a pediatric injury surveillance database, by reporting its findings. Pedalcyclists was one categorization, with separate information provided for this group of subjects. Again, because the primary purpose of the manuscript was not the evaluation of head injuries, the study was not included in the sub-grouping of head entries.

Due to the noted style of data reporting, more accurate and reliable head injury data was seriously limited. The initial definitions provided above were used consistently throughout this manuscript when evaluating entries by type of injuries sustained, with the exception of those entries identified here.

Reference will be made to "entries", or used interchangeably with the word "studies", to denote the number of citations contributing information to a given analysis. The reason for this is twofold: 1.) Some of the studies included in this review did not exclusively evaluate bicyclists, but rather injuries as a whole sustained in a defined population, one of which was bicycling, and 2.) Some studies evaluated more than one sample of cyclists, or more than one intervention. Thus, although more applicable to observational studies than non-observational studies (only one study contributed two entries in the evaluation of helmet usage and type of accident data analyses; i.e., Thompson et al. 1989), a single study may have provided more than one outcome estimate, when more than one group of subjects or interventions was evaluated.

Non-Observational Studies

General Study Information

In evaluation of the general study information and characteristics of non-observational based bicycle-related research, the majority of studies were published between 1990-1994 (n=16, 32%), were located in medical journals (n=39, 78%), and were written by physicians (n=31, 62%) who were associated with academic/teaching institutions (n=28, 56%). Studies were nearly equally distributed among the Northeast (n=10, 20%), Midwest (n=11, 22%), and West (n=12, 24%), with the Southeast (n=7, 14%) and Southwest (n=4, 8%) serving as the site of fewer studies. Expectedly, retrospective studies prevailed, accounting for 66% (n=33) of all studies.

Subject Characteristics

The detail in which subject characteristics were reported varied greatly. All studies described the age of subjects, some more detailed than others. Most studies (n=31, 62%) evaluated both children and adults. Investigators limiting their subject population to children followed (n=16, 32%), with adult only subject populations forming the minority of studies (n=3, 6%). Unfortunately, age categories were not consistent among investigators. Many investigators provided age ranges and mean or median values, but failed to provide tables with age categories and frequencies (Yelon et al. 1995; Ashbaugh et al. 1995; Nakayama et al. 1990; Agran and Winn 1993; Largo and Thacher-Renshaw

1993; Watts et al. 1986; Tucci and Barone 1988; Walker and Raines 1982; Westman and Morrow 1984). Other investigators created age categories, but these categories were not uniformly selected by all investigators. Examples of the diverse age categories include: 0-4, 5-9, 10-14, 15-19 (Li et al. 1995; Ernster and Gross 1982; Runyan et al. 1985; Friede et al. 1985); 0-4, 5-14, 15-24, 25-34, etc. (Warren et al. 1995); 0-4, 5-9, 10-14, 15-19, 20-24, 25-29, etc. (Zavoski et al. 1995; Sacks et al. 1991); 0-4, 5-9, 10-14, 15-19, 20-24, 25-44, etc. (Thompson et al. 1990); 0-9, 10-19, 20-29, 30-39, etc. (Spaite et al. 1991); < 15, 15-24, 25+ (Annegers et al. 1980; Thompson et al. 1989); 3-6, 7-9, 10-12, 13-16 (McKenna et al. 1991); ≤ 11, 12-16, ≥ 17 (Fife et al. 1983); < 16, ≥ 16 (Hawley et al. 1995); ≤ 9, 10-14, 15-24, 25-34, etc. (Cowan et al. 1993; Rodgers 1995); < 15, 15-39, 40-59, 60+ (Rivara et al. 1989); ≤ 15, 16-44, ≥ 45 (Whitman et al. 1984); 1-18 (Selbst et al. 1987); 18-22, 23-27, 28-32, etc. (Belongia et al. 1988); < 16, 16-25, ≥ 25 (Halek et al. 1980); ≥ 21 (Frank et al. 1995).

The most plausible split in the age categories appeared to be at < 15 years, and ≥ 15 years (Annegers et al. 1980; Ernster and Gross 1982; Whitman et al. 1984; Friede et al. 1985; Runyan et al. 1985; Rivara et al. 1989; Thompson et al. 1989; Thompson et al. 1990; Sacks et al. 1991; Agran and Winn 1993; Cowan et al. 1993; Li et al. 1995; Rodger 1995; Zavoski et al. 1995). However, although these authors had a similar age classification, not all had data for related information, such as helmet usage, and complete injury patterns (Friede et al. 1985; Runyan et al. 1985; Thompson et al. 1990; Sacks et al. 1991; Agran and Winn 1993; Zavoski et al. 1995). In addition, a small number of these studies focused on head injuries (n=3) (Annegers et al. 1980; Cowan et al. 1993; Li et al. 1995). However, even among these three studies, the operational definition of head injury varied, and would have necessitated further extrication of data.

Problems similar to those noted above, also plagued the non-observational bicycle-related injury and helmet literature in relation to the remaining potential confounding variables, namely ethnicity (n=42, 84% did not specify the race of the subjects, with n=45, 90% unable to provide helmet usage comparison by race), socioeconomic status (n=48, 96% not able - with n=43, 86% not providing any SES information), and highest level of education attained by primary household member (n=48, 96% did not report education information). Thus, the lack of necessary descriptive statistics required to code and analyze study data, precluded the evaluation of many hypotheses of interest.

Injury Profile

The injury profile of bicyclists reported by the majority of investigators reviewed, typically failed to report comparative bicycle injury data by helmet usage. Of those researchers that did report helmet usage, 4 (8%) noted that no bicyclist was wearing a helmet at the time of their accident, thereby prohibiting effect size estimates from being calculated (Ashbaugh et al. 1995; Yelon et al. 1995; Hawley et al. 1995; Fife et al. 1983). Among these 4 studies, the sample population of 2 studies was comprised exclusively of bicyclist fatalities (Hawley et al. 1995; Fife et al. 1983). Among the 7 investigators in this review who either focused on, or restricted their sample population to head injured subjects, only 3 (43%) reported bicycle helmet usage for the head injured cyclists (Li et al. 1995;

Jaffe et al. 1993; Belongia et al. 1988). Although this may appear alarming, 3 of 4 remaining studies took place before 1985 and sought to evaluate head injuries by all mechanism, one of which was bicycle-related (Annegers et al. 1980; Klauber et al. 1981; Whitman et al. 1984). The remaining study however, aimed to "examine the relationship of brain injury to bicyclists within a population-based survey of all brain injuries in San Diego County, California," (Kraus et al. 1987, p. 76). Because this is a frequently referenced study of bicycle helmet advocates, it was surprising that the researcher failed to compare helmeted versus non-helmeted cyclists.

Figure 7:

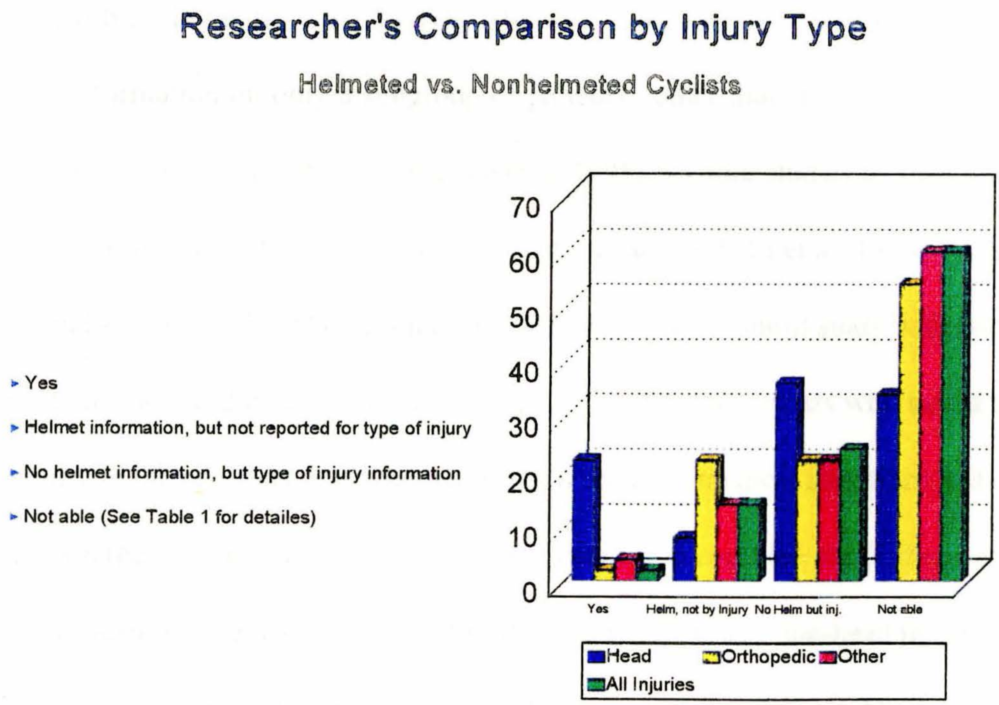


Figure 7 displays the composition of studies by the researcher's comparison of helmeted versus non-helmeted injured cyclists by type of injury, specifically head, orthopedic, "other," and all injuries. Noticeably, only 22% (n=11) of the studies provided enough information for comparisons between helmeted and non-helmeted head injured cyclists to be made. The effect size estimates from these studies are presented in Tables 2 - 4. The calculation of the effect size estimates for this set of studies was performed in several ways, to determine if effect size estimates would produce significantly different findings depending upon the manner in which they were calculated or grouped. This was an important consideration among this group of studies, due to the sample populations selected for acquisition of data. The various sample groupings include: 1.) one study evaluated bicycle fatalities exclusively (Boswell et al. 1996), 2.) three studies reported helmet information on only a subgroup of patients, rather than all patients (Watts et al. 1986; Tucci and Barone 1988; and Warren et al. 1995), 3.) four studies focused on bicycle-related head injuries (Belongia et al. 1988; Jaffe et al. 1993; Li et al. 1995; Warren et al. 1995) and 4.) one study (Thompson et al. 1989) was a case-control study with two control populations (nonhead injured bicyclists, and HMO affiliated cyclists who stated that they had injury in the previous year whether or not it required medical attention) and one case population (head injured cyclists). This author decided to combine the findings of injured bicyclists seen in the emergency room (head injured cyclists and non-head injured cyclists) into one sample, versus the less structured HMO control population. The reason for this decision was two-fold: 1.) the authors provided enough information to make this possible, and 2.) it seemed more consistent with the hypotheses that this author was seeking to assess in relation to bicycle-related injuries. Furthermore, because the author of the study included ear injuries, forehead only injuries, facial injuries and other nonhead or brain injuries into the head injured group, separation of these subjects from the more stringent head or brain injury sought by this author was not possible.

Tables 2 and 3 present the effect size estimates calculated using both the complete sample size, and subset sample size, which effected only the above 3 mentioned studies, in the calculation of effect size estimates. Noticeably, no significant difference was found between the two methods of estimation. Both sets of results indicated that most injured cyclists were reportedly not wearing a helmet at the time of the accident ((d = -2.6623, 95% CI = -2.72, -2.61 based on the overall sample size) (Table 2), and (d = -2.6373, 95% CI = -2.69, -2.58 when the subset sample size was used in the estimation of effect sizes) (Table 3)). However, both analyses failed to meet the assumption of homogeneity, thereby indicating that the effect size estimates should probably not be pooled for a common estimate of effect size in this set of studies (Q = 8120.496, $p < 0.00005$ and 8044.058, $p < 0.00005$, respectively). Note that Q_w represents a weighted homogeneity statistic, when a weight is applied to the effect sizes (Johnson 1993, p.7). As such, the Q_w statistic will not be interpreted throughout this manuscript, as no weights were applied to the effect sizes. Rather, each study was weighted by one.

Examination of the r-statistic associated with both sets of analyses revealed r-values (r = -0.7995), which were significant ($p < 0.00005$). Thus, in the test of the hypothesis of whether there is a correlation between helmet usage and incurring a bicycle-related injury, we would conclude that there is a significant association between incurring an injury and not wearing a bicycle helmet. More specifically, non-helmet use explains approximately 64% of the variance in subjects who incurred a bicycle-related injury. The size of the correlation coefficient may be influenced by a number of factors, including the severity of injuries of those seeking medical or hospital treatment in comparison to the large number of bicyclists not incurring any injury or only minor injuries not requiring medical attention. Keep in mind however, that failure of the estimated mean weighted effect size measure to comply with the homogeneity assumption, suggests that this estimate does not adequately depict the outcome of interest in the representative studies. Review of the individual d estimates and associated 95% CI's provided in Tables 2 and 3 indicate that the magnitude of individual study outcomes varied greatly (-0.3715 to -13.0325), which likely contributed to the lack of homogeneity found.

Disregarding the heterogeneity noted above, further examination of the relevant studies for potential sources of inconsistencies was done. A mean weighted effect size was calculated separately for the 4 studies that concentrated on bicycle-related head injuries excluding the remaining 11 general bicycle injury studies (Table 4), and alternately for the 11 general bicycle-related injury studies while omitting the 9 studies that focused on bicycle-related head injured patients (Table 5). Examination of Tables 4 and 5 reveal a lack of homogeneity for each respective sub-group of studies. However, a notable reduction in d, the mean weighted effect size or composite effect size measure, was noted (d = -7.1435 for the studies focusing on bicycle-related head injuries, and d = -1.9876 for the general bicycle related injury studies). Note that the d value indicates the difference between the mean levels of injury for the two groups (helmeted and nonhelmeted) divided by a standard deviation that is assumed to be common to the two groups. Because a positive d value represents differences in the helmeted direction, these results suggest that injured bicyclists as a whole, are more likely than the sub-group of bicycle-related head injured subjects, to be wearing a helmet at the time of their accident. Nonetheless, the significant difference between helmeted and non-helmeted injured cyclists in both analyses was found ($p < 0.00005$) in the presence of low power, and with a composite effect size that could not adequately represent all studies (heterogeneity). Therefore, this author cautions against making any definitive inferences to the general population of bicyclists.

In lieu of the significant difference between helmeted and non-helmeted injured cyclists and with continued disregard of the heterogeneity among this set of studies, closer examination of the two meaningful results were noted in the examination of bicycle-related head injured subjects only (Table 4). First, the correlation coefficient increased from -0.7995 (Table 3) to -0.9630 (Table 4), thereby indicating an increase in the amount of shared variance between sustained bicycle-related injuries and helmet non-usage. Second, despite a substantial reduction in the Q statistic, it remained significant, thereby indicating the presence of heterogeneity among the group of studies that examined bicycle-related head injured cyclists ($Q = 230.225$; $p < 0.00005$). Thus, although the two variables (helmet usage/nonusage and bicycle-related head injuries requiring medical attention) share a moderately large amount of variance between them ((@93%), even among studies examining bicycle-related head injuries, some studies found large differences in favor of helmeted cyclists, some found small differences in favor of helmeted cyclists, and some studies reported differences in favor of nonhelmeted cyclists.

Similar to the bicycle-related head injury studies, separate examination of the effect size estimates for the 11 studies that assessed bicycle-related injuries in general, while excluding the 4 studies whose primary emphasis was on head injuries, also demonstrated a substantial reduction in the Q statistic ($Q = 3910.294$; $p < 0.00005$). Accordingly, although on average helmeted cyclists were found to be injured less than nonhelmeted cyclists, the results of the studies included in this review are inconsistent, as implied by the failure of the studies to comply with the assumption of homogeneity (Refer to Table 5). More precisely, some studies found large differences against of nonhelmeted cyclists, some studies found small differences against nonhelmeted cyclists, and some studies produced outcomes against helmeted cyclists.

Table 2: Helmet versus Non-Helmet Injury Data based on Overall Sample Size (Non-Observational Studies)

Helmet Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Thompson	-1.9148	-2.09 / -1.74	-.6923	.0000	+0.823	-76.746
2-Selbst	-13.0325	-13.61 /-12.46	-.9885	.0000	-10.460	%-1268.644
3-Watts	-2.1375	-2.36 / -1.92	-.7312	.0000	+0.558	-23.560
4-Tucci	-4.7243	-5.16 / -4.29	-.9216	.0000	-2.093	-87.116
5-Frank	-4.7797	-5.09 / -4.47	-.9228	.0000	-2.182	-186.338
6-Warren	-3.4927	-3.95 / -3.03	-.8696	.0000	-0.842	-12.734
7-Belongia	-9.9770	-10.97 / -8.98	-.9808	.0000	-7.336	-207.564
8-Jaffe	-5.4429	-6.47 / -4.41	-.9412	.0000	-2.788	-28.022
9-Li-1	-7.4369	-7.60 / -7.28	-.9657	.0000	-5.354	%-3767.975
10-Thompson2a	-1.6671	-1.79 / -1.54	-.6407	.0000	+1.216	-300.031
11-Thompson2b	-1.2616	-1.39 / -1.13	-.5341	.0000	+1.689	-550.479
12-Gerberich	-4.5493	-4.78 / -4.31	-.9157	.0000	-1.988	-260.444
13-Spaite	-0.7842	-0.94 / -0.63	-.3657	.0000	+2.132	-650.796
14-Stutts-1a	-5.9264	-6.18 / -5.67	-.9476	.0000	-3.415	-671.052
15-Spaite-2	-0.3715	-0.54 / -0.21	-.1831	.0000	+2.552	-816.101
Overall:	-2.6623	-2.72 / -2.61	-.7995	.0000	3.028	-593.840

```
Note: Q(14)=  8120.496; p = 0.0000;
d's are positive for differences in the Helmeted direction.
effect sizes corrected for bias.
      sums are: TWD =-3628.496  TWDS = 17780.5  TW = 1362.938
 Largest outlier is Li-1
```

```
Qw( 14 ) =  8120.496; p = 0.0000;
     sums are: TWD =-3628.496 ; TWDS = 17780.5 ; TW = 1362.938 .
     Dev.= deviation of d from the mean d excluding d.
     The marginal for Dev. is the average absolute deviation.
     Homo.= amount of reduction to Qw if effect size removed.
     The marginal for Homo. is average reduction per effect size.
     This table was created using DSTAT 1.11 on 10-16-1997 at 11:00:02,
     and these data were written to OUTPUT.DST.  The raw effect sizes
     are stored in the file HELMET.DAT.
```

End-of-Output

Table 3: Helmet versus Non-Helmet Injury Data Based on Subset Sample Size

(Non-Observational Studies)

Helmet Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Thompson	-1.9148	-2.09 / -1.74	-.6923	.0000	+0.797	-71.867
2-Selbst	-13.0325	-13.61 /-12.46	-.9885	.0000	-10.487	%-1275.003
3-Watts	-2.1368	-2.37 / -1.91	-.7312	.0000	+0.529	-19.051
4-Tucci	-4.6280	-5.58 / -3.67	-.9216	.0000	-1.997	-16.757
5-Frank	-4.7797	-5.09 / -4.47	-.9228	.0000	-2.209	-190.886
6-Warren	-3.4810	-4.02 / -2.94	-.8696	.0000	-0.852	-9.434
7-Belongia	-9.9770	-10.97 / -8.98	-.9808	.0000	-7.361	-208.997
8-Jaffe	-5.4429	-6.47 / -4.41	-.9412	.0000	-2.813	-28.529
9-Li-1	-7.4369	-7.60 / -7.28	-.9657	.0000	-5.396	%-3817.765
10-Thompson2a	-1.6671	-1.79 / -1.54	-.6407	.0000	+1.192	-286.585
11-Thompson2b	-1.2616	-1.39 / -1.13	-.5341	.0000	+1.667	-533.476
12-Gerberich	-4.5493	-4.78 / -4.31	-.9157	.0000	-2.017	-267.699
13-Spaite	-0.7842	-0.94 / -0.63	-.3657	.0000	+2.110	-635.526
14-Stutts-1a	-5.9264	-6.18 / -5.67	-.9476	.0000	-3.445	-682.055
15-Spaite-2	-0.3715	-0.54 / -0.21	-.1831	.0000	+2.531	-800.444
Overall:	-2.6373	-2.69 / -2.58	-.7968	.0000	3.027	-589.605

Note: Q(14)= 8044.058; p = 0.0000;
d's are positive for differences in the Helmeted direction.
effect sizes corrected for bias.
sums are: TWD =-3516.308 TWDS = 17317.62 TW = 1333.298
Largest outlier is Li-1

Qw(14) = 8044.058; p = 0.0000;
sums are: TWD =-3516.308 ; TWDS = 17317.62 ; TW = 1333.298 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-16-1997 at 10:50:21,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file HELMET1.DAT.

End-of-Output

Note however, in comparison to the studies examining helmet versus nonhelmeted bicyclists sustaining a head injury, this analysis produced a smaller d statistic and associated 95% CI (d = -1.9876, 95% CI = -2.05, -1.93). Recall that the d statistic and associated 95% CI for the studies focusing on bicycle-related head injuries were d = -7.1435 and -7.29 to -6.99, respectively. The less negative d statistic would indicate that although incurring bicycle-related injuries in general is associated with non-helmet use, it is even more influential when assessing bicyclists incurring head injuries. However, the narrower 95% CI associated with the d statistic found in the analysis of studies examining bicycle injuries in general, implies less variability, or error, in the estimation of helmet usage among studies evaluating bicycle injuries in general versus those evaluating bicycle-related head injuries. Lastly, while both correlation coefficients were found to be significant ($p < 0.00005$) - a finding that could be attributed to the manner in which the probability value was calculated, the amount of shared variance between helmet non-usage and bicycle-related injuries was less for studies reviewing bicycle injuries in general ($r = -.7049$, $r^2 = 50\%$), when compared with those studies reviewing bicycle-related head injuries ($r = -.9630$, $r^2 = 93\%$). Therefore, although helmet non-usage accounts for more variance in the examination of bicycle-related head injuries (93%) than it does in the examination of bicycle related injuries in general (50%), the precision with which the associated d statistic is calculated is better for studies reporting bicycle-related injuries in general, than for those who assessed bicycle-related head injuries exclusively. In addition, the previously noted lack of homogeneity among effect size estimates, further impedes any definitive conclusions. A more detailed discussion of potential explanations for the heterogeneity noted among this group of studies, is discussed in the proceeding chapter.

In consideration of the findings noted above, namely that the composite effect size estimates assessing helmet usage among injured cyclists revealed that entries emphasizing bicycle-related head injuries (d = -7.1435, 95% CI = -7.29 to -6.99), versus those reporting bicycle-related injuries in general (d = -1.9876, 95% CI = -2.05 to -1.93), found that the magnitude of differences for non-helmet usage was greater for cyclists sustaining head injuries, an analysis of variance (ANOVA) procedure was conducted to determine whether this difference was significant, or could be attributed to the usual sample variability that could be found in a sample population. Using the effect size estimates obtained in the meta-analytic procedure, the ANOVA procedure found no significant difference in helmet usage between bicyclists who had sustained head injuries, and those who had incurred an injury in general ($F_{1,13} = 2.0149$, $p = 0.1793$) (See Table 6). Thus, although a directional difference in the magnitude of the calculated effect size estimates between cyclists incurring a head injury and those sustaining any form of injury, is visibly apparent, ANOVA procedures revealed that the difference is not greater than that which could expected by chance.

The impact of bicycle helmet campaigns on minimizing the occurrence of head injuries sustained by cyclists, could only be assessed through the examination of the directional differences in the magnitude of the measured effect size estimates. This reason for this was the small number of entries focusing on head injuries that provided data adequate for a meta-analysis (n=4). Although an increase in helmet usage was noted, as evident by some less negative effect size estimates, no consistent increasing trend was observed among all four studies (See Table 4). Rather, an increasing trend was apparent between the earliest published study (1988) and one of the most recently published studies (1995), as evident by the greatest improvement in the effect size estimate (d = -9.9770 for 1988 study, and d = -3.4810 for 1995 study). The two middle studies (one published in the 1993, and one in 1995) revealed a fluctuation in helmet usage among head injured cyclists, with the following corresponding effect size estimates: -5.4429, and -7.4369, respectively. Thus, despite the numerous interventions aimed at reducing the number of bicycle-related head injuries by increasing helmet usage, that had been promulgated through the years 1988-1995, including global media campaigns, and specific strategies, such as legislation, education, and joint education and community approaches, a simultaneous consistent reduction in the effect size estimates were not noted.

Table 4: Helmet versus Nonhelmet Injury Data for Studies Emphasizing Bicycle-Related Head Injuries Only (Non-Observational Studies)

Helmet Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Thompson	This case was marked and excluded in this analysis					
2-Selbst	This case was marked and excluded in this analysis					
3-Watts	This case was marked and excluded in this analysis					
4-Tucci	This case was marked and excluded in this analysis					
5-Frank	This case was marked and excluded in this analysis					
6-Warren	-3.4810	-4.02 / -2.94	-.8696	.0000	+3.973	-190.939
7-Belongia	-9.9770	-10.97 / -8.98	-.9808	.0000	-2.900	-31.790
8-Jaffe	-5.4429	-6.47 / -4.41	-.9412	.0000	+1.738	-10.683
9-Li-1	-7.4369	-7.60 / -7.28	-.9657	.0000	-2.392	-103.459
10-Thompson2a	This case was marked and excluded in this analysis					
11-Thompson2b	This case was marked and excluded in this analysis					
12-Gerberich	This case was marked and excluded in this analysis					
13-Spaite	This case was marked and excluded in this analysis					
14-Stutts-1a	This case was marked and excluded in this analysis					
15-Spaite-2	This case was marked and excluded in this analysis					
Overall:	-7.1435	-7.29 / -6.99	-.9630	.0000	2.751	-84.218

```
Note: Q(3)=   230.225; p = 0.0000;
d's are positive for differences in the Helmeted direction.
effect sizes corrected for bias.
      sums are: TWD =-1200.209  TWDS = 8803.88  TW = 168.015
 Largest outlier is Warren
```

```
Qw( 14 ) =   230.225; p = 0.0000;
      sums are: TWD =-1200.209 ; TWDS = 8803.88 ; TW = 168.015 .
      Dev.= deviation of d from the mean d excluding d.
      The marginal for Dev. is the average absolute deviation.
      Homo.= amount of reduction to Qw if effect size removed.
      The marginal for Homo. is average reduction per effect size.
      This table was created using DSTAT 1.11 on 10-16-1997 at 10:53:58,
      and these data were written to OUTPUT.DST.  The raw effect sizes
      are stored in the file HELMET1.DAT.
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End-of-Output

Table 5: Helmet versus Nonhelmet Injury Data for General Bicycle-Related Injury Studies Only (Non-Observational Studies)

Helmet Data
No label entered yet

Study	d	95% CI	r	p	Dev.	Homo.
1-Thompson	-1.9148	-2.09 / -1.74	-.6923	.0000	+0.081	-0.740
2-Selbst	-13.0325	-13.61 /-12.46	-.9885	.0000	-11.157	%-1441.202
3-Watts	-2.1368	-2.37 / -1.91	-.7312	.0000	-0.159	-1.707
4-Tucci	-4.6280	-5.58 / -3.67	-.9216	.0000	-2.650	-29.493
5-Frank	-4.7797	-5.09 / -4.47	-.9228	.0000	-2.892	-325.684
6-Warren	This case was marked and excluded in this analysis					
7-Belongia	This case was marked and excluded in this analysis					
8-Jaffe	This case was marked and excluded in this analysis					
9-Li-1	This case was marked and excluded in this analysis					
10-Thompson2a	-1.6671	-1.79 / -1.54	-.6407	.0000	+0.407	-32.330
11-Thompson2b	-1.2616	-1.39 / -1.13	-.5341	.0000	+0.907	-153.229
12-Gerberich	-4.5493	-4.78 / -4.31	-.9157	.0000	-2.724	-484.386
13-Spaite	-0.7842	-0.94 / -0.63	-.3657	.0000	+1.398	-273.482
14-Stutts-1a	-5.9264	-6.18 / -5.67	-.9476	.0000	-4.153	-984.847
15-Spaite-2	-0.3715	-0.54 / -0.21	-.1831	.0000	+1.836	-414.190
Overall:	-1.9876	-2.05 / -1.93	-.7049	.0000	2.579	-376.481

```
Note: Q(10)=  3910.294; p = 0.0000;
d's are positive for differences in the Helmeted direction.
effect sizes corrected for bias.
     sums are: TWD =-2316.099  TWDS = 8513.738  TW = 1165.283
 Largest outlier is Selbst
```

```
Qw( 14 ) =  3910.294; p = 0.0000;
     sums are: TWD =-2316.099 ; TWDS = 8513.738 ; TW = 1165.283 .
     Dev.= deviation of d from the mean d excluding d.
     The marginal for Dev. is the average absolute deviation.
     Homo.= amount of reduction to Qw if effect size removed.
     The marginal for Homo. is average reduction per effect size.
     This table was created using DSTAT 1.11 on 10-16-1997 at 10:51:52,
     and these data were written to OUTPUT.DST.  The raw effect sizes
     are stored in the file HELMET1.DAT.
```

End-of-Output

Table 6: Analysis of Variance Summary Table Results: Helmet Usage in Cyclists Sustaining Head Injuries versus All Forms of Injuries Combined

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	23.7686	23.7686	2.0149	.1793
Within Groups	13	153.3561	11.7966		
Total	14	177.1247			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	11	-3.7408	3.6091	1.0882	-6.1655	TO	-1.3162
Grp 2	4	-6.5874	2.7748	1.3874	-11.0026	TO	-2.1722
Total	15	-4.4999	3.5569	.9184	-6.4697	TO	-2.5301

GROUP	MINIMUM	MAXIMUM
Grp 1	-13.0325	-.3715
Grp 2	-9.9770	-3.4927
TOTAL	-13.0325	-.3715

Levene Test for Homogeneity of Variances

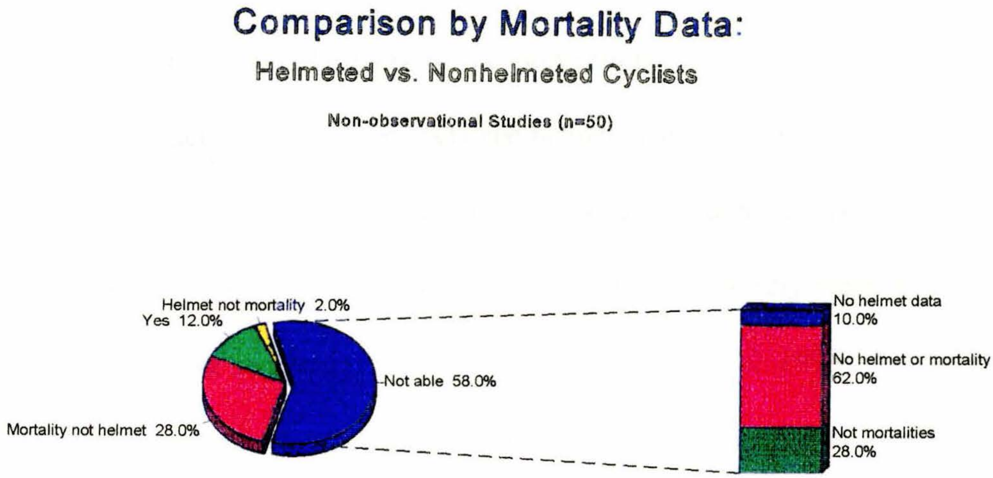
Statistic	df1	df2	2-tail Sig.
.1453	1	13	.709

* Group 1: Entries reporting general bicycle-related injures, Group 2: Entries emphasizing bicycle-related head injuries.

The examination of the role bicycle helmets play in injuries incurred elsewhere in the body was not assessable. The composition of the researcher's comparison of helmeted versus non-helmeted injuries for orthopedic injuries, 'other injuries,' (defined as non-head, non-orthopedic, and comprised predominately of vascular or internal injuries), and all injuries (studies which included at least two of the above categories - head, orthopedic, or 'other' injuries, or just reported injuries without specifying an anatomic location or classification), is presented in Table 1 and displayed graphically, along with head injuries, in Figure 7. The failure of the majority of researcher's to adequately report helmet use among non-head injured cyclists impeded any examination into the potential existence of repercussions, or potential drawbacks, from donning a bicycle helmet. More specifically, this author sought to examine whether an increase in neck injuries (distinguished from head injuries) were experienced by injured bicyclists wearing a helmet at the time of their accident.

Evaluation of the role bicycle helmets play in the prevention of bicycle-related mortalities, was also troubled by lack of reports of comparisons for helmeted and non-helmeted cyclists (See Table 1 and Figure 8). Table 1 indicates that only 10% (n=5) of all 50 studies reported such comparisons (Boswell et al. 1996; Frank et al. 1995; Stutts et al. 1990; Thompson et al. 1989; Belongia et al. 1988), with only 4 studies revealing that bicycle-related mortalities were more commonly experienced by those not wearing a bicycle helmet (Frank et al. 1995; Stutts et al. 1990; Thompson et al. 1989; Belongia et al. 1988).

Figure 8:

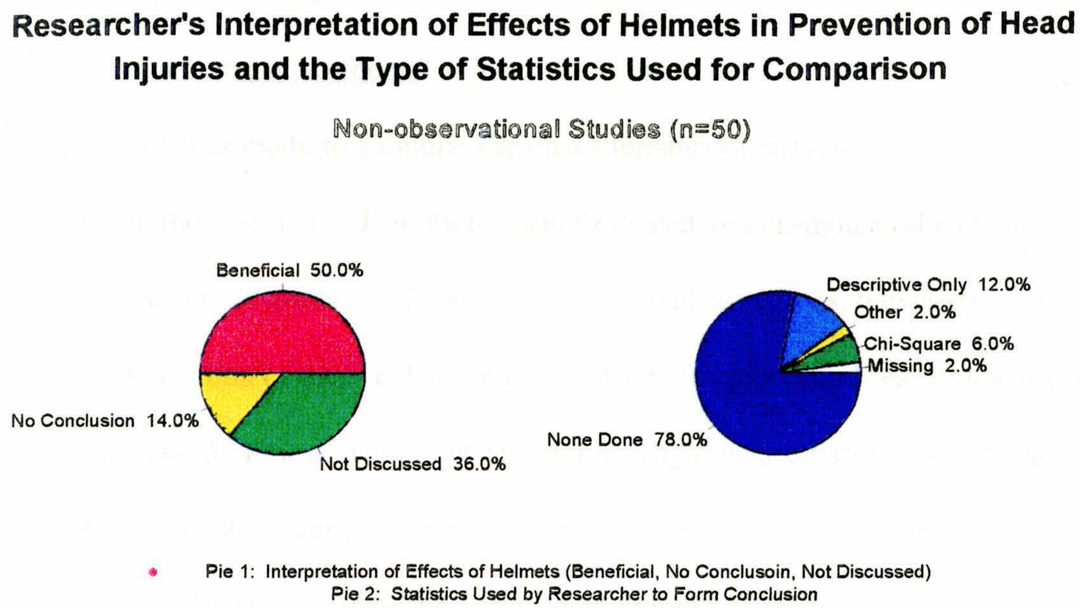


The predilection of researchers to infer that bicycle helmets were beneficial in the prevention of head injuries without any statistical techniques being done to support their conclusions was prevalent among the researchers reviewed (n=25, 50%) (See Table 1 and Figure 9). The preponderance of studies reported no statistical evidence (n=39, 78%), while 6 (12%) studies descriptively reported data to support their claim (Boswell et al. 1996; Jaffe et al. 1993; Stutts et al. 1990; Thompson et al. 1990; Belongia et al. 1988; Watts et al. 1986). Conversely, Li and associates (1995), Spaite and associates (1991), and Thompson and colleagues (1989) reported chi-square statistics. Sacks and associates

(1991) reported relative risk estimates based on the literature, while Gerberich et al. (1994) failed to mention the type of statistics used.

Most troublesome however, was the conclusions made by numerous authors as to the efficaciousness of bicycle helmets in the prevention of injuries, particularly head injuries, without any actual comparisons between helmeted and non-helmeted cyclists ever being made (n=13, 26%). Of the thirteen studies that made such a judgement, 2 (15%) were unable to make comparisons because no subject was reportedly wearing a bicycle helmet at the time of the accident (Fife et al. 1983; Ashbaugh et al. 1995). However, 10 (10/13, 77%) studies not providing helmet/non-helmet injury comparisons concluded that helmets were beneficial in the prevention of injuries (Williams et al. 1976; Klauber et al. 1981; Friede et al. 1985; Kraus et al. 1987; King et al. 1991; Sacks et al. 1991; Li et al. 1992; Agran and Winn 1883; Largo and Thacher-Renshaw 1993; Zavoski et al. 1995). Only 4 (8%) studies used statistical analysis in their assessment of the effectiveness of bicycle helmets (Thompson et al. 1989; Spaite et al. 1991; Frank et al. 1995; Li et al. 1995), all of which found them to be beneficial in the prevention of head injuries. Six studies (12%) descriptively reported the benefit of bicycle helmet usage over nonusage (Watts et al. 1986; Belongia et al. 1988; Tucci and Barone 1988; Stutts et al. 1990; Thompson et al. 1990; Jaffe et al. 1993). In contrast, both Gerberich and associates (1994) and Boswell and colleagues (1996) reported no difference in injury rates among helmeted and non-helmeted cyclists.

Figure 9:

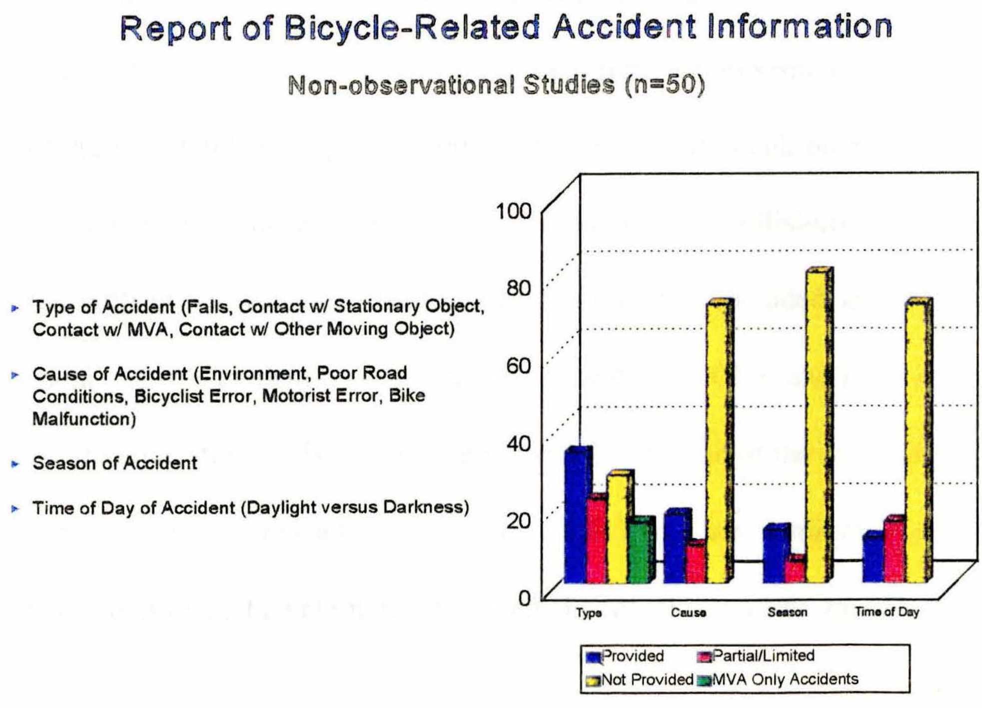


The overwhelming acceptance of helmets as the definitive solution to reducing bicycle-related injuries, particularly head injuries, among the studies reviewed here, appears to have been based more on concepts perceived to be obvious by medical professionals, injury prevention researchers, educators, and legislators, rather than actual scientific evidence. However, it is this author's belief that if legislation is to be mandated that has the potential to take away a very simple pleasure of our youth, namely riding a bicycle, simply because the child's family could not afford to purchase a bicycle helmet, we may be doing more harm than good. Not only have the majority of researcher's reviewed here failed to include minorities and lower income families in their studies, but their studies have also lacked comparisons among helmeted and non-helmeted cyclists to show a more definitive benefit of their use.

Characteristics of Bicycle Accidents

An effort was made to examine the characteristics of bicycle-related accidents. Exploration into the type of accident (motor-vehicle related, or non-motor vehicle related), cause of the accident (environmental conditions, poor road conditions, bicyclists error, or motorist error), location of the accident (major roadway, neighborhood/residential street, bike path/park/school), time of day of the accident (daylight versus darkness), and season of the accident, were all variables of interest. Among these variables, only type of accident was regularly detailed (n=17, 34%, see Table 1 and Figure 10).

Figure 10:



Accordingly, the effect size estimates, associated confidence intervals, correlation coefficients and corresponding p-values are presented in Table 7. The mean weighted effect size, d, is -5.4198, with an associated 95% CI of -5.42 that does not include zero. This suggests that a significant difference exists between the number of bicyclists sustaining injuries from bicycle versus motor vehicle collisions and bicycle versus non-motor vehicle collisions, with most people incurring their injuries from accidents that did not involve a motor vehicle. The 95% CI values, almost identical to the actual d estimate itself, suggest the variance of variable is restricted.

Further review of the results reveal a rather high correlation coefficient ($r = -.9382$), lending support to the finding that the subjects experiencing a bicycle accident, generally are involved in non-motor vehicle collision. More specifically, bicycle-non-MVA accidents accounted for approximately 88% of the variance among bicyclists sustaining an injury while riding. Nonetheless, similar to earlier estimates, lack of homogeneity indicates that a single effect size measure cannot adequately form a composite effect size for these studies ($Q(23) = 95077.039$, $p < 0.00005$). As a result, although on average bicyclists incurred their injuries more often from non-motor vehicle collisions rather than from collisions with motor vehicles, the findings from studies included in this review are inconsistent. This is evident by examination of the d, 95% CI, r, and p-value associated with the individual studies. Both the magnitude and direction of the effect size estimates varied substantially from one another (-9.4746 to 5.6173). Thus, some studies found large differences supporting bicycle-non-motor vehicle collisions, some studies found small differences supporting bicycle-non-motor vehicle collisions, and some studies produced outcomes lending support in the direction of bicycle-motor vehicle collisions. Therefore, prior to any definitive evaluation, further analyses would be required to examine the inconsistencies among motor vehicle versus non-motor vehicle bicycle injuries. A formal attempt to explain some of the inconsistency would involve examination of various study characteristics or qualities, to determine their effect on the magnitude of the effect sizes. However, the general inconsistencies among studies preclude this author from performing these more advanced model testing procedures.

In lieu of the above restrictions, outlier analyses and examination of similar groups of study effect sizes were done. Removal of the study effect size that resulted in the largest reduction in the Q statistic was performed sequentially until a non-significant Q statistic was obtained. Table 8 presents the results of this statistical procedure. Noticeably, only 5 of 24 studies remained, for a Q statistic = 8.467 and associate p-value of 0.0759 (Kraus et al. 1987; King et al. 1991; Frank et al. 1995; Zavoski et al. 1995; Ashbaugh et al. 1995). The resultant mean effect size (d = -0.7251), was noticeably less than that when all studies were included (d = -5.4198), and the 95% CI widened from -5.42 previously to (-0.79 to -0.66). Therefore, the mean effect size remained significant, as evident by a CI that did not include zero, indicating that significantly more bicyclists are injured as a result of an accident not involving a motor vehicle than from a collision with a motor vehicle. Furthermore, all 5 studies tended to find the same outcome (homogeneity achieved). The associated increase in the width of the confidence interval however, is likely to be a function of fewer studies (i.e., decreased sample size from 24 to 5), rather than a change in the standard error.

In light of the above finding, this author sought to examine the 5 studies for obvious similarities. Visual displays were not created, effect sizes plotted again predictors, to identify the presence of abnormalities among the effect sizes, due to the very small number of effect sizes. However, a review of some fundamental characteristics of the studies was performed. A pediatric subject population was assessed by King et al. 1991 and Ashbaugh and associates 1995, while Kraus and colleagues (1988) focused on all bicycle-related brain injuries. Lastly, Frank and associates (1995) and Zavoski and colleagues (1995) included both injured adult and child cyclists. The data collection period for these studies ranged from 1987-1993 for all but Kraus and associates' (1987) study, who collected data during 1981. The principal author of all but one study was an MD, the other being a Ph.D. researcher, and data for each was obtained from hospital records. Three studies took place on the East Coast, while 2 were undertaken on the West Coast. Finally, only one manuscript was published in a non-medical journal, specifically, a public health journal. Thus, no overt differences in general study characteristics, were noted among these five studies.

Table 7: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA (Non-Observational Studies)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	-0.7456	-0.82 / -0.67	-.3495	.0000	+4.690	%-14809.117
2-Ashbaugh	-0.2289	-0.61 / +0.16	-.1154	.2412	+5.192	-696.109
3-Selbst	-1.7618	-1.90 / -1.62	-.6615	.0000	+3.661	%-2508.938
4-Friede	-2.2800	-2.43 / -2.13	-.7522	.0000	+3.143	%-1713.516
5-Ernester	-1.5808	-1.93 / -1.24	-.6235	.0000	+3.840	-477.336
6-Halek	+5.6173	+5.15 / +6.08	+.9425	.0000	+11.038	%-2143.711
7-Yelon	+0.0945	-0.21 / +0.40	+.0476	.5387	+5.515	%-1275.945
8-Largo	-1.4592	-1.77 / -1.15	-.5922	.0000	+3.961	-638.180
9-Watts	-0.0394	-0.21 / +0.13	-.0198	.6571	+5.384	%-3663.563
10-Tucci	-2.8196	-3.14 / -2.50	-.8170	.0000	+2.601	-259.461
11-McKenna	-6.8495	-7.36 / -6.34	-.9602	.0000	-1.430	-29.930
12-King	-0.8970	-1.18 / -0.61	-.4118	.0000	+4.524	-948.133
13-Frank	-0.6700	-0.83 / -0.51	-.3183	.0000	+4.753	%-3324.258
14-Hawley	+1.0866	+0.58 / +1.59	+.4857	.0000	+6.507	-645.602
15-Boswell	+1.2000	-0.15 / +2.55	+.6000	.0515	+6.620	-92.844
16-Rodgers-1b	+2.1317	+2.02 / +2.25	+.7296	.0000	+7.562	%-16698.789
17-Belongia	-2.2134	-2.47 / -1.96	-.7433	.0000	+3.207	-596.352
18-Kraus	-0.7177	-0.90 / -0.54	-.3386	.0000	+4.705	%-2608.492
19-Jaffe	+0.2315	-0.25 / +0.71	+.1176	.3357	+5.652	-539.359
20-Li-1	-0.0746	-0.13 / -0.02	-.0373	.0108	+5.376	%-33498.762
21-Thompson-2a	-1.8509	-1.98 / -1.72	-.6796	.0000	+3.573	%-2981.961
22-Thompson-2b	-9.4746	-9.88 / -9.06	-.9785	.0000	-4.055	-375.398
23-Stutts-1a	-1.7310	-1.86 / -1.60	-.6549	.0000	+3.693	%-3216.203
24-Flora	-5.5104	-5.51 / -5.51	-.9400	.0000	-4.891	%-87566.484
Overall:	-5.4198	-5.42 / -5.42	-.9382	.0000	4.816	%-7554.518

Note: Q(23)= 95077.039; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-1091184 TWDS = 6009065 TW = 201333.4
Largest outlier is Flora

Qw(23) = 95077.039; p = 0.0000;
sums are: TWD =-1091184 ; TWDS = 6009065 ; TW = 201333.4 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 08-12-1997 at 19:06:45,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file MVANOMVA.DAT.

End-of-Output

Table 8: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA
Stepwise Removal of Outliers

MVA/NonMVA - Grp 1 Data (Non-Observational Studies)

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	-0.7456	-0.82 / -0.67	-.3495	.0000	-0.062	-0.853
2-Ashbaugh	-0.2289	-0.61 / +0.16	-.1154	.2412	+0.509	-6.527
3-Selbst	This case was marked and excluded in this analysis					
4-Friede	This case was marked and excluded in this analysis					
5-Ernester	This case was marked and excluded in this analysis					
6-Halek	This case was marked and excluded in this analysis					
7-Yelon	This case was marked and excluded in this analysis					
8-Largo	This case was marked and excluded in this analysis					
9-Watts	This case was marked and excluded in this analysis					
10-Tucci	This case was marked and excluded in this analysis					
11-McKenna	This case was marked and excluded in this analysis					
12-King	-0.8970	-1.18 / -0.61	-.4118	.0000	-0.180	-1.434
13-Frank	-0.6700	-0.83 / -0.51	-.3183	.0000	+0.065	-0.524
14-Hawley	This case was marked and excluded in this analysis					
15-Boswell	This case was marked and excluded in this analysis					
16-Rodgers-1b	This case was marked and excluded in this analysis					
17-Belongia	This case was marked and excluded in this analysis					
18-Kraus	-0.7177	-0.90 / -0.54	-.3386	.0000	+0.008	-0.007
19-Jaffe	This case was marked and excluded in this analysis					
20-Li-1	This case was marked and excluded in this analysis					
21-Thompson-2a	This case was marked and excluded in this analysis					
22-Thompson-2b	This case was marked and excluded in this analysis					
23-Stutts-1a	This case was marked and excluded in this analysis					
24-Flora	This case was marked and excluded in this analysis					
Overall:	-0.7251	-0.79 / -0.66	-.3408	.0000	0.165	-1.869

Note: Q(4)= 8.467; p = 0.0759;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-734.4443 TWDS = 541.0206 TW = 1012.872
Largest outlier is Ashbaugh

Qw(23) = 8.467; p = 0.0759;
sums are: TWD =-734.4443 ; TWDS = 541.0206 ; TW = 1012.872 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed..
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 08-12-1997 at 19:10:21,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file MVANOMVA.DAT.

End-of-Output

Examination of potential sources of inconsistency among bicyclists injured via bicycle-motor vehicle accidents and bicycle-non-motor vehicle accidents was explored in more detail by focusing on differences in the sample population. A mean weighted effect size, adjusted for sample size and using the same set of 24 studies, was calculated for the following subsets of studies: 1.) all studies, except for the 3 studies that included only fatally injured bicyclists (Appendix D-1), 2.) all studies, except for the 5 studies which focused on bicycle-related head injuries (Appendix D-2), 3.) all studies with the exception of those focusing on both bicycle-related head injured victims and fatally injured bicyclists (Appendix D-3), 4.) exclusion of all studies except for those focusing on both bicycle-related head injured victims and fatally injured bicyclists (Appendix D-4), 5.) exclusion of all studies except for those focusing on bicycle-related head injured victims (Appendix D-5), and 6.) exclusion of all studies except for those which included only fatally injured cyclists (Appendix D-6).

Keeping in mind that no study that included only bicycle-motor vehicle collisions or bicycle-non-motor vehicle collisions were included, due to the inability to estimate an effect size measure, none of the above 6 subset analyses examining bicycle injuries resulting from both collisions with motor vehicles and other non-motor vehicle collisions, resulted in a non-significant Q statistic (Refer to Table 9). Thus, the effect size estimates remain inconsistent despite the sub-groupings, and should not be pooled for a composite effect size estimate. Therefore, although this author will comment on the above findings, care should be made not to deduce any inferences to the general population.

Table 9: Results of Analyses Attempting to Explain Inconsistencies Among Studies in the Examination of Bicycle-Related Injuries by Type of Accident

Type of Study	d	95% CI for d	r corresponding to d	p-value for r	Q-statistic and p-value
Fatality Only Studies Excluded (Appendix D-1)	-5.4313	-5.44, -5.43	-0.9384	0.0000	Q(20)=77638.578 p < 0.00005
Head Injury Studies Only Excluded (Appendix D-2)	-5.4551	-5.46, -5.45	-0.9389	0.0000	Q(19)=57780.039 p < 0.00005
Head and Fatality Studies Excluded (Appendix D-3)	-5.4668	-5.47, -5.46	-0.9391	0.0000	Q(16)=40175.730 p < 0.00005
Head and Fatality Studies (Appendix D-4)	0.2076	0.16, 0.26	0.1033	0.0000	Q(6)=1630.069 p < 0.00005
Head Injury Studies (Appendix D-5)	-0.2179	-0.27, -0.16	-0.1083	0.0000	Q(3)=287.703 p < 0.00005
Fatality Studies (Appendix D-6)	2.0739	1.96, 2.19	0.7198	0.0000	Q(2)=17.458 p = 0.0002

Despite the continued presence of heterogeneity among studies, some interesting results were found. Appendix D-3 displays detailed results of the analysis of studies that examined bicycle injuries in general. Excluded from this analyses were two subsets of studies: those whose study criteria included only subjects who had sustained a head injury as a result of a bicycle accident (4 studies), and those investigators who examined only bicycle fatalities (3 studies). The exclusion of both of these types of studies while maintaining all general bicycle-related injury studies, resulted in the greatest reduction in the Q statistic ($Q(16) = 40175.730$, $p < 0.00005$), and largest correlation coefficient ($r = -0.9391$), thereby accounting for more variance than any other analyses incorporating all of the studies evaluating bicycle related injuries in general (17 studies).

The greatest improvement in the Q statistic, however, was noted in the analysis that included only fatality studies ($Q(2) = 17.458$, $p = 0.0002$) (Table 9 & Appendix D-6). A positive mean weighted effect size ($d = 2.0736$) and widened 95% CI (1.96 to 2.19), again probably attributable to the small sample size, was noted. Because positive d values favor bicycle-motor vehicle collisions, this finding lends crecidence to the concept that more bicycle fatalities may be attributed to bicycle-motor vehicle collisions, than collisions not involving motor vehicles.

Examination of those studies which focused principally on bicycle-related head injuries, excluding all others, also produced a reduced Q statistic ($Q(3) = 287.703$, $p < 0.00005$) injuries, but the reduction was not as great as that for fatality studies alone. Moreover, the composite correlation coefficient accounted for substantially less variance ($r = -0.1083$). Interestingly though, the mean weighted effect size measure was negative ($d = -0.2179$, 95% CI = -0.27 to -0.16). This implies that unlike bicycle fatality victims, head injured bicyclists are more likely to sustain their injuries as a result of a non-motor vehicle collision. Additional evidence supporting the impact of motor vehicles in bicycle fatalities was found in the concurrent examination of both bicycle-related head injury studies, and studies assessing only bicycle fatalities, while excluding all other studies reviewing bicycle-related injuries as a whole (Table 9 & Appendix D-4). The results of this analysis yielded a positive mean weighted effect size measure, a 95% CI that did not include zero ($d = 0.2076$, 95% CI = 0.16 to 0.26), and reduced Q statistic ($Q\ (6) = 1630.069$, $p < 0.00005$). Noticeably, the reduction in the Q statistic was not sufficient enough to render the effect size estimates homogenous. The inconsistency in individual study outcomes will be momentarily overlooked, in an attempt to evaluate the above findings that may aide in the explanation the noted heterogeneity.

The results found by estimating a composite effect size measure for studies examining either bicycle fatalities or subjects who incurred bicycle-related head injuries, implied that a significant difference exists among injuries sustained by bicyclists involved in collisions with motor vehicles versus those incurring injuries via another type of accident (Refer to Appendix D-4). In particular, fatally injured cyclists and cyclists sustaining a head as a result of their accident, appeared to be more commonly involved in collisions with motor vehicles, as evident by the positive d value, and 95% CI that did not include zero.

The simultaneous evaluation of all sub-groups of analyses (Table 9 & Appendi 4- 6), appeared to provide additional support to an already prevailing position. Specifically, these results favor the concept that while bicycle collisions with motor vehicles are more likely to result in cyclist fatalities, they are less likely to result in the cyclist incurring a head injury. Evidence for this assertion is provided by the data displayed Table 9; all of which was presented in more detail above. Observably, two analyses produced a positive mean weighted effect size estimate: 1.) the integration of the 3 fatality studies, and 2.) the combination of both fatality and head injury studies. However, although combining both fatality and head injury entries produced a positive mean weighted effect size (d = 0.2076), pooling only bicycle-related head injured entries resulted in a negative mean weighted effect size estimate (d =-0.2179). Considered together, these results appear support the literature and medical evidence that fatally injured cyclists are more likely to be involved in collisions with motor vehicles, than surviving cyclists sustaining any type of injury. Hence, notwithstanding the limitations imposed by lack of homogeneity, the number of studies (4 and 3, respectively) included in these analyses are also clearly too small to make any powerful conclusions beyond that of suggestive findings in favor of concepts already noted in the literature. Any attempt to draw definitive conclusions based on these findings would be imprudent.

Based on the findings noted above, two ANOVA procedures were performed to determine whether a significant difference existed among the directional differences in magnitude noted above. Accordingly, the effect size estimates obtained from the above procedures, and displayed in Table 7, were used. The dependent variable of both ANOVA procedures was the differences in occurrence of accident types (between bicycle-motor vehicle collisions and bicycle-non-motor vehicle collisions). The independent variable was the type of injury sustained. In the first ANOVA procedure, type of injury was grouped into three categories: general bicycle-related injuries, head injuries and fatal injuries. In the second ANOVA procedure, type of injury was grouped into two categories: general bicycle-related injuries and head/fatal injuries. The second analysis was run to get an idea of the role accident type may have on injury severity, with head and fatal injuries being perceived to be reflective of more severe injuries. However, because severity was not directly measured, the results of the latter ANOVA should viewed as informational, and not a definitive analysis findings.

The results of the ANOVA procedures are presented in Tables 10 and 11. A non-significant test statistic was found for both ANOVA procedures. Table 10 indicates that fatally injured cyclists were no more likely to be involved in collisions with a motor-vehicle than non-fatally injured bicyclists, including bicyclist incurring a head injury as a result of a bicycle collision ($F_{2,21} = 1.8725$ $p = 0.1785$). Similarly, Table 11 reveals that cyclists incurring a variety of injuries (general injury studies) are just as likely to be involved in a collision with a motor vehicle than cyclists seeking treatment for injuries that are (typically) more severe (head and fatal) ($F_{1,22} = 2.7588$, $p = 0.1109$). In addition, note that unlike the meta-analytic procedures, the assumption of homogeneity was not violated in either ANOVA procedure, thus implying that the mean of each group did adequately describe its constituent effect sizes.

Application of a one-tailed directional test, based on the current injury prevention literature, that assumes that both fatally injured and head injured cyclists are more likely to be involved in a collision with a motor vehicle than injured bicyclists in general, would not have changed the results of the ANOVA procedures. Notice that dividing the p-values of the above two ANOVA procedures by 2, produces significance levels equal to 0.08925 and 0.05545, respectively. Moreover, although the latter one-tailed analysis, testing the hypothesis that head and fatally injured bicyclists are more often than injured bicyclists in general to sustain their injuries as a result of a collision with a motor vehicle, would produce a p-value equal to 0.05545, consideration would also need to be given to the number of statistical tests performed on this data set. More specifically, no adjustment in the p-value was made for the multiple tests conducted. Thus, lowering the p-value to a level that would have permitted this author to account for the several exploratory analyses performed, while still maintaining the chosen probability ($p = 0.05$) of making a Type I error, would have required an extremely small alpha level. Therefore, selection of either a one-tailed directional hypothesis over the two-tailed nondirectional hypothesis, or a probability level adjusted for the many analyses performed, would not have altered the outcome of the analyses.

Table 10: Analysis of Variance Summary Table Results: Differences in Injury Sustained by Type of Accident Difference Scores

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	30.5029	15.2514	1.8725	.1785
Within Groups	21	171.0435	8.1449		
Total	23	201.5464			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	17	-1.8933	3.2291	.7832	-3.5536	TO	-.2331
Grp 2	4	-.6935	1.0877	.5439	-2.4243	TO	1.0372
Grp 3	3	1.4728	.5735	.3311	.0482	TO	2.8973
Total	24	-1.2726	2.9602	.6043	-2.5226	TO	-.0226

GROUP	MINIMUM	MAXIMUM
Grp 1	-9.4746	5.6173
Grp 2	-2.2134	.2315
Grp 3	1.0866	2.1317
TOTAL	-9.4746	5.6173

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.1195	2	21	.345

**Group 1: General bicycle injury entries, Group 2: Entries focusing on head injuries, Group 3: Bicycle fatality entries.

Table 11: Analysis of Variance Summary Table Results: Differences in Injury Sustained by Type of Accident Difference Scores (General Injury vs Head/Fatal Injuries)

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	22.4578	22.4578	2.7588	.1109
Within Groups	22	179.0885	8.1404		
Total	23	201.5464			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	17	-1.8933	3.2291	.7832	-3.5536	TO	-.2331
Grp 2	7	.2349	1.4290	.5401	-1.0867	TO	1.5565
Total	24	-1.2726	2.9602	.6043	-2.5226	TO	-.0226

GROUP	MINIMUM	MAXIMUM
Grp 1	-9.4746	5.6173
Grp 2	-2.2134	2.1317
TOTAL	-9.4746	5.6173

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.0839	1	22	.309

**Group 1: General bicycle injury entries, Group 2: Entries focusing on head injuries combined with bicycle fatality entries.

Summary

The meta-analytic results of the two outcomes assessed here, helmet usage among injured bicyclists, and bicyclists sustaining injuries via bicycle-motor vehicle collisions or bicycle-non-motor vehicle collisions, both revealed significant heterogeneity problems. The dissimilarity in the collection of important confounding variables, fairly homogenous sub-samples, and varying levels of reported statistics likely played a role in these problems. Furthermore, the substantive lack of uniformity, and inability to account for the systematic variance in the studies in this meta-analysis, prevented the results of this study from being used for explanatory purposes. Notwithstanding the above limitations, useful information can be abstracted. Examination of the mean weighted effect sizes for clues rather than evidence, and the performance of analysis of variance procedures using those measures in the assessment of the outcomes of interest (as appropriate), revealed the following:

1.) Most injured cyclists were not wearing a helmet at the time of their injury.

2.) Although head injured subjects appeared to be less likely than injured cyclists as a whole, to be wearing a helmet at the time of their accident, the difference in helmet usage was found to be not significant.

3.) Fatally injured cyclists were no more likely to be involved in a collision with a motor vehicle than non-fatally injured cyclists, including those who had incurred a head injury as a result of their accident.

In an attempt to provide insight into the above findings, studies that had effect size estimates for both measurable postulates of interest, namely, the impact of bicycle helmets on bicycle-related injuries, and the influence type of collision had on bicycle-related injuries, were reviewed for similarities and differences. Of the 28 studies used to assess one of the two hypotheses of interest, 10 studies were common to both (Watts et al. 1986; Selbst et al. 1987; Belongia et al. 1988; Thompson et al. 1989 (x2); Tucci and Barone 1988; Stutts et al. 1991; Jaffe et al. 1993; Frank et al. 1995; Li et al. 1995). However, integration of a sub-group of these studies in a meta-analytic procedure to assess each hypothesis of interest, still resulted in significant Q values ($Q(9) = 6055.272$, $p < 0.00005$; $Q(9) = 3333.128$, $p < 0.00005$ respectively), implying inconsistency among studies for each postulate tested (See Appendix E). Table 12 displays the results obtained when the ten studies common to both analyses described above, were grouped together. Noticeably, this group of studies produced results similar to those noted above. A significant negative d value was obtained for each analyses suggesting that most injured cyclists were not wearing a helmet at the time of their accident, and that the majority of bicycle accidents did not involve a collision with a motor vehicle, respectively. However, as mentioned above, neither model adequately represented the data as evident by a significant homogeneity test for each of the analyses.

Table 12: Results of Analyses Obtained by Grouping Studies Common to Both Postulates Tested: Helmet vs. Non-Helmet Injury Data and Impact of MVA Collisions in Bicycle-Related Injuries

Type of Study	d	95% CI for d	r corresponding to d	p-value for r	Q-statistic and p-value
Helmet vs. Non-Helmet Injury Data (Appendix E-1)	-3.3216	-3.39, -3.25	-0.8567	0.0000	Q(9)=6055.272 p < 0.00005
MVA vs. Non-MVA Bike Injury Data (Appendix E-2)	-0.8111	-0.85, -0.77	-0.3758	0.0000	Q(9)=3333.128 p < 0.00005

Analysis of variance (ANOVA) procedures were also performed on the sub-group of 10 studies that provided sufficient data for the calculation of effect size estimates for each of the hypotheses performed. Two ANOVA procedures were done, one for each hypothesis addressed. Effect size estimates resulting from the corresponding meta-analytic procedures were used. Tables 13 and 14 display below, present the ANOVA summary table results from these procedures. No significant difference was found between the effect size estimates representing helmet usage patterns for cyclists treated for general injuries, versus those treated for head injuries ($F_{1,8} = 1.2477$, $p = 0.2964$) (Refer to Table 13). Similarly, the results of the ANOVA procedure done to evaluate the influence type of accident has on the kind (and indirectly the severity) of injuries sustained, also revealed a nonsignificant finding ($F_{1,8} = 0.9966$, $p = 0.3474$) (Refer to Table 14). Therefore, this data indicates that no significant relationship exists between the type of accident a cyclist is involved in (motor-vehicle versus non-motor vehicle), and sustaining a head injury. Please note, that while the entries comprising the head injury group focused exclusively or almost entirely on bicycle-related head injuries, entries comprising the general injury group included bicyclists incurring any type of injury, a small percentage of which included head injuries (typically).

Table 13: Analysis of Variance Summary Table Results: Comparison of Helmet Usage by Injury Types (10 Studies Providing Sufficient Data for Meta-Analysis)

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	16.9726	16.9726	1.2477	.2964
Within Groups	8	108.8255	13.6032		
Total	9	125.7981			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	7	-4.7760	4.0517	1.5314	-8.5232	TO	-1.0289
Grp 2	3	-7.6189	2.2725	1.3120	-13.2643	TO	-1.9736
Total	10	-5.6289	3.7387	1.1823	-8.3034	TO	-2.9544

GROUP	MINIMUM	MAXIMUM
Grp 1	-13.0325	-1.2616
Grp 2	-9.9770	-5.4429
TOTAL	-13.0325	-1.2616

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.4123	1	8	.539

**Group 1: General bicycle-related injury entries, Group 2: Head focused bicycle-related injury studies.

Table 14: Analysis of Variance Summary Table Results: Comparison of Accident Type by Injury Types (10 Studies Providing Sufficient Data for Meta-Analysis)

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	7.8673	7.8673	.9966	.3474
Within Groups	8	63.1543	7.8943		
Total	9	71.0216			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	7	-2.6210	3.1519	1.1913	-5.5360	TO	.2939
Grp 2	3	-.6855	1.3320	.7690	-3.9945	TO	2.6235
Total	10	-2.0404	2.8091	.8883	-4.0499	TO	-.0308

GROUP	MINIMUM	MAXIMUM
Grp 1	-9.4746	-.0394
Grp 2	-2.2134	.2315
TOTAL	-9.4746	.2315

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.5273	1	8	.488

**Group 1: General bicycle-related injury entries, Group 2: Head focused bicycle-related injury studies.

Examination of the fundamental characteristics of the 10 entries included in the summary analyses for non-observational studies revealed no profound differences that were overtly discernable between these studies. A preponderance of the studies were published in medical journals, by physicians, and were fairly equally distributed by region. Children were exclusively studied by 3 researchers, with the remaining including bicyclists of all ages. The data for all but 2 studies was collected prior 1988, and thus before many of the bicycle helmet campaigns. However, all were published during, or after the initial promulgation of such campaigns (1986-1995). This finding is disheartening, as studies exposing the role various confounders play in the purchase, use, and efficacy of bicycle helmets were in print, and could have been investigated and incorporated into the analyses.

In lieu of these findings, any provisional inferences drawn from these results must be done so with caution, due to the noted heterogeneity among studies. The deficiency in consistent reporting of confounding variables (e.g., race, SES, highest education level of primary household member), and design attributes in the original studies, precluded the detection of any pattern of correlations among relevant variables. Moreover, an explicit method of unraveling the variability of the outcomes of interest, such as blocking on subject or study characteristics, was not possible. Researchers may consider incorporating any number of stratification variables to aide future investigators in uncovering some of the variability in the effect sizes noted here. Furthermore, failure of these analyses to support the prevailing opinions held by researchers advocating compulsory bicycle helmet legislation, regarding helmet usage and accident type, may be the impetus needed for researchers to improve upon the quality of study methods used to assess their hypotheses of interest. In addition, it may also prompt investigators to be more receptive to the notion that a more definition solution to the reduction in the number of bicycle-related head injuries sustained each year by cyclists, of all ages, has yet to be discovered.

Observational Studies

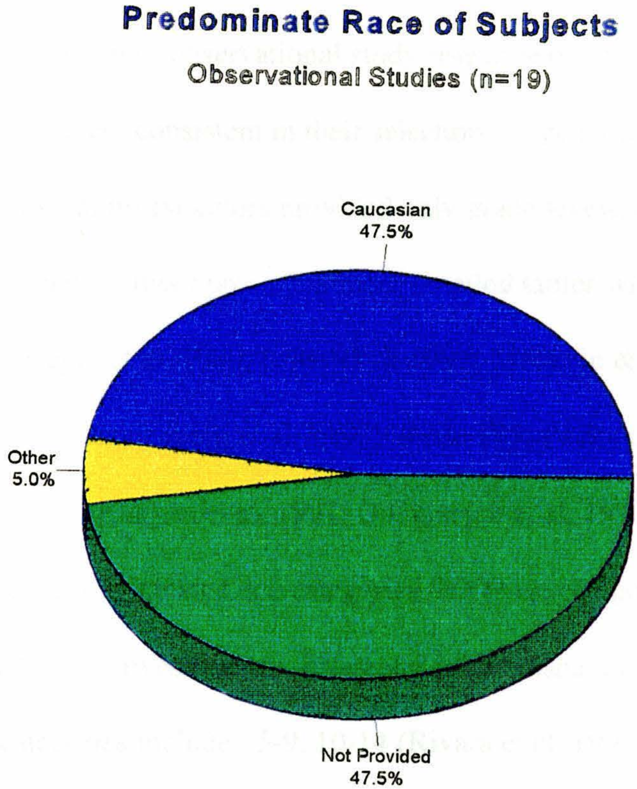
General Study Information

General study characteristics of the bicycle-related literature utilizing observational techniques had several similarities with concurrent non-observational studies in the same area. Most studies were published in medical journals (n=12, 57%) between 1990-1994 (n=13, 62%), and were written by physicians (n=15, 72%) who were associated with academic/teaching institutions (n=14, 67%). In contrast to the non-observational studies, observational studies were obviously prospective, with the greatest percentage of studies implemented in the Northeast (n=7, 37%). This was an unanticipated finding that has the potential to contribute to differences in riding patterns, cyclist experience, and subsequent factors influencing bicycling accidents. Evidence for this rationale is provided by data published by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in reference to fatal bicycle-automobile accidents. According to the 1994 *Traffic Facts Report*, examination of the percentage of all traffic crash fatalities that resulted from bicycle-automobile collisions in 1994 in each state, revealed higher percentages for warmer climate states (0.6%, 4.5%, median % = 2.0%) than that noted in colder climate states (0.0% - 4.5%, median % = 1.6%). Various characteristics of bicyclists, including socioeconomic levels (poverty areas), experience riding a bicycle, feasibility of riding a bicycle (e.g., community to work and school via a bicycle would be prohibited during the colder months in states that experience snow and ice), recreational vacations which involve cycling by residents of colder climates in warmer climate states, and year-round cycling ability, may all contribute to the reported national differences. In turn, these factors may all influence the efficacy of bicycle helmet campaigns and legislative measures long-term. This issue will be addressed in more detail in an ensuing section of this chapter.

Subject Characteristics

The report of characteristics of the sample under investigation appeared more detailed than that previously noted by authors of non-observational studies. The majority of authors reported bicycle specific gender information (n=14, 74%), and all reported age categories. A preponderance of authors evaluated children exclusively (n=10, 53%), followed by those including both children and adults in their study design. Although confounding factors, such as ethnicity (n=7, 37%), SES (n=4, 21%), and highest level of education attained by primary household member (n=5, 26%) were reported more frequently by observational researchers than that previously noted by non-observational researchers, (10%, 6%, and 2%, respectively), those reporting such information were in the minority. Of those researchers detailing the ethnicity of their subjects, caucasions overwhelming prevailed (n=9, 47.5%), with only 1 study (5%) having a preponderance of minorities (See Figure 11).

Figure 11:



Methodological Issues and Injury Profiles

The typical study investigated one experimental group (n=11, 58%), and had greater than 300 subjects (n=17, 90%). No specific type of campaign was evaluated by most investigators (n=7, 37%). Among those researchers interested in the effectiveness of a particular intervention in achieving their outcome, campaigns with both educational and community components were most popular (n=6, 32%). The primary outcome measure assessed by most investigators was helmet usage (n=8, 42%), followed closely by those interested in both helmet usage and helmet purchase (n=7, 37%). Observation was the principal method selected by authors to evaluate helmeted versus non-helmet cyclists (n=7, 37%).

In comparison to non-observational study researchers, observational study researchers were even less consistent in their selection of age categories for data documentation. Several investigators provided only grade levels, or age ranges and mean or median values, without providing more detailed tables with age categories and frequencies (DiGuiseppi et al. 1989; Liller et al. 1995; Macknin & Mendendorp 1994; Schneider et al. 1993; Dannenberg et al. 1993; Weiss 199; Puczynski & Marshall 1992; Pendergrast et al. 1992; Runyan et al. 1991; DiGuiseppi et al. 1990; Kimmel et al. 1990). Other investigators created age categories, but these categories were not uniformly selected by all investigators. Examples of the disparate, yet often overlapping age categories include: 5-9, 10-14 (Rivara et al. 1994); 5-13, 14-21, >21 (Rouzier & Alto 1995), < 13, 13-19, ≥ 20 (Cote et al. 1992; Dannenberg et al. 1993); 3-12, with individual age frequencies for each age (Waller 1971); ≤ 10, 11-20, 21-30, 31-40, 41-50, > 50 (Rodgers 1995); 11-19, 20-29, ≥ 30 (Wasserman et al. 1988); and 18-20, 21-24, 25-29, 30-34, ≥ 35 (Fullerton and Becker 1991).

Similar to non-observational study investigators, examination of the influence confounders had on the outcomes of interest was not uniformly reported by observational researchers. Directional comparisons between helmet and non-helmeted cyclists by age groups, gender, SES and highest level of education attained by the primary household member contained 5 or fewer total studies, thereby thwarting the calculation of a composite effect measure. Too few studies, and thus low power impeded the estimation of a composite effect size measure for directional comparisons of helmeted and nonhelmeted cyclists by type of injury. Similar problems were also encountered in the attempt to integrate various reported bicycle accident characteristics (type of accident, cause of accident, season of accident, time of day of accident, and location of accident). Race was the only variable with helmet versus nonhelmet directional information reported in more than 5 studies (a total of 6 studies). Table 15 presents the effect size estimates and composite effect size measure adjusted for sample size; i.e., the tendency for small samples to inflate the population effects. Noticeably, the homogeneity statistic, Q, is significant ($Q = 53.652$, $p = 0.00005$), thus revealing that comparisons between helmet and nonhelmeted cyclists yielded effect size measures for ethnicity (defined as whites versus non-whites) for each study, that are significantly large to reject the hypothesis that they were drawn from a common population. Once again, this implies that it is inappropriate to interpret the composite effect size estimate, or d. Thus, although the d-statistic (0.2334) found on average, that whites were more likely to be helmeted than non-whites, they also noted heterogeneity in the outcomes of these studies ($Q(7)$ 53.65, $p < 0.00005$). More specifically, some investigators noted large differences in favor of whites, other found smaller differences in favor of whites, and still others (1 in this case), found differences in favor of non-whites. Furthermore, the inclusion of only 8 studies also raises the question as to how realistic our estimate is in relation to our investigated postulate, due to the extremely small sample size.

Overlooking the problem of heterogeneity, closer examination of the racial effect size estimates for each study or d, the difference between the mean levels of race (whites/nonwhites) for helmeted cyclists, divided by a standard deviation that is assumed to be the same for both groups of cyclists, revealed a discernible pattern favoring whites. This is evident by a positive composite d, or mean weighted effect size (@ .20), with associated composite CI not including zero (CI = 0.19 to 0.28), thereby suggesting that helmet usage is significantly different for race. Furthermore, because a positive d indicates that more whites than nonwhites were helmeted, and the effect size estimates were all positive, whites were more likely than nonwhites to be helmeted in each study.

However, although all effect size estimates possessed positive values, not all 95% CI's associated with those values, were significant. Thus, racial differences in helmet usage, following an adjustment for sample size, were not significantly different at the 95% significance level in the following four entries: Liller and associates (1995), Dannenberg and colleagues (1993 x 2), and Cote and colleagues (1992). In relation to this finding, it is important to note that three of the entries are dependent, representing data acquired from the same area, and evaluating the same interventions. A similar pattern was found when looking at the correlation coefficients and corresponding p-values. The composite correlation coefficient associated with d was, $r = 0.1159$. Although this is significant ($p < 0.00005$), its significance likely stems from the manner in which it was calculated. More specifically, the p-value associated with the correlation coefficient provided by the DSTAT program, is "based on the total sample size for all studies" (Johnson, 1989). Nonetheless, the correlation coefficient itself ($r = 0.1159$), implies that little variance is shared between race and helmet usage (approximately 1.3%). The four entries with non-significant effect size estimates also had lower correlation coefficients, and thus higher p-values. Interestingly, these four entries also included the fewest percentages of minorities in their sample population; a point that will be discussed in more detail below.

The lack of correlation between race and helmet usage found in this analysis could have been influenced by a variety of reasons. Two of the most probable reasons however, are the small percentage of minorities included in the studies for which effect size estimates were calculated, and the finding that of the minorities observed, at times none were wearing a helmet, thereby preventing effect size estimates from being calculated. More specifically, the proportion of whites in each of the studies included in the analyses were as follows:

1.) Liller and associates' (1995) study = 87%,

2.) Rivara and associates' (1994) study = 79%,

3.) Fullerton and Becker's (1991) study = 70%,

4.) DiGuiseppi and associates' (1989) study = 76%,

5.) Dannenberg and associates' (1993) study: Howard County = 96%, Baltimore County = 97%, and Montgomery County = 93%.

6.) Cote and colleagues' (1992) study: Howard County = (88%)

Note 1: Effect size estimates for Howard County were obtained by summing helmet usage practices observed at both the baseline and follow-up observation periods, due to few minorities observed at follow-up (n=6). In addition, the aim of the hypothesis was to determine if differences in helmet usage existed between races, not whether the intervention was successful.

Note 2: Effect size estimates for helmet usage by race were not calculated for either Baltimore or Montgomery County because no minorities observed were wearing a helmet, thereby not permitting effect size estimates to be calculated.

Certainly, the above data do not appear to be representative of the general population to which inferences are made - an assumption made when calculating correlations. The over-sampling of middle and upper-middle class communities may have contributed to the lower percentage of minorities observed. Therefore, because a known relationship exists between SES and race, excluding or restricting lower income areas from selected observation sites, almost guarantees that minorities will be under-represented. This may create a point estimate for the population of middle and upper-middle class members of a community (generalized to the population), thereby resulting in an artificial correlation coefficient. This is an important issue, because legislative decisions that do not discriminate between races and socioeconomic status are, and likely will continue to be made, based on the results of studies like these.

Evidence in support of the concept that racial differences likely play a role in helmet usage patterns, is provided by looking at both the d values presented in Table 15, and the percentage of whites included in the sampled populations. Notably, the studies with the lowest percentage of whites, although still overwhelmingly in the majority, namely Fullerton and Becker (1991), Rivara and associates (1994), and DiGuiseppi and colleagues (1989), produced a significant effect size measure, as manifested by CI's that did not include zero. Considered together, the above findings led a sub-group analysis to determine the mean weighted effect size estimate for the 4 studies with the greatest percentage of minorities (the above 3 studies, plus Liller and associates' (1995) study). The results of this analysis are presented in Table 16. In comparison, the estimation of a mean weighted effect size measure for the 4 studies whose sample population included a greater percentage, albeit not majority, of minority cyclists is presented in Table 17.

Examination of the results presented in Tables 16 and 17 concur with the above postulate. The results indicate that across the 4 entries with the greatest percentage of whites (Dannenberg et al. 1993 - x 3 (all counties observed), and Cote et al. 1992), helmet usage is significantly different among whites and non-whites, in favor of whites ($d = 0.4437$, CI = 0.26 to 0.63), and that as expected, the data is consistent ($Q(3) = 4.614$, $p = 0.2024$). Ironically, it is these two studies from which the 4 entries were extricated, that form the landmark research referenced by many helmet advocates and policy makers regarding the effectiveness of legislation (in Howard County, Maryland) in increasing helmet usage among cyclists. Unfortunately, the overwhelming percentage of whites (88-97%) observed, is clearly not representative of the general population. Plausible explanations for this include an over-sampling, or complete sampling, of observational sites in predominately white neighborhoods, and/or in middle and upper-middle class communities. Regardless of the reason, the resulting sample population of both studies do not adequately represent the population as a whole, but rather concentrate on one racial group - a practice that has been shown to produce biased results (Spikler, 1991).

Table 15: Helmet versus Nonhelmet Usage Data by Race (Observational/Survey Studies)

race-grp2

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+0.1782	-0.23 / +0.59	+.0889	.0372	-0.056	-0.071
2-Dannenberg-Balt	+0.1999	-0.27 / +0.67	+.0996	.0178	-0.034	-0.020
3-Dannenberg-Mont	+0.6270	+0.37 / +0.88	+.2994	.0000	+0.405	-9.268
4-Fullerton	+0.7823	+0.30 / +1.26	+.3669	.0003	+0.553	-5.110
5-Cote-HowCo	+0.4170	-0.14 / +0.98	+.2054	.0238	+0.185	-0.416
6-Liller	+0.0371	-0.29 / +0.36	+.0186	.7423	-0.200	-1.429
7-Rivara-#110	+0.7868	+0.60 / +0.97	+.3664	.0000	+0.585	-35.406
8-DiGuiseppi-#111	+0.1851	+0.14 / +0.23	+.0921	.0000	-0.363	-31.165
Overall:	+0.2334	+0.19 / +0.28	+.1159	.0000	0.298	-10.361

```
Note: Q(7)=     53.652; p = 0.0000;
d's are positive for differences in the white-helmeted direction.
effect sizes corrected for bias.
      sums are: TWD = 478.5842  TWDS = 165.3714  TW = 2050.168
 Largest outlier is Rivara-#110
```

```
Qw( 7 ) =     53.652; p = 0.0000;
      sums are: TWD = 478.5842 ; TWDS = 165.3714 ; TW = 2050.168 .
      Dev.= deviation of d from the mean d excluding d.
      The marginal for Dev. is the average absolute deviation.
      Homo.= amount of reduction to Qw if effect size removed.
      The marginal for Homo. is average reduction per effect size.
      This table was created using DSTAT 1.11 on 08-12-1997 at 22:04:35,
      and these data were written to OUTPUT.DST.  The raw effect sizes
      are stored in the file RACE-G2.DAT.
```

End-of-Output

Like the entries with the greatest percentage of whites (88-97%), the results from the data of 4 entries integrated from among those with the fewest whites (70-87%) (Table 17), similarly showed that racial disparities exist among helmeted cyclists, with more whites than non-whites donning bicycle helmets (d = 0.2214, CI = 0.18 to 0.27).

However, unlike the above analysis integrated across the 4 entries from overwhelmingly white subjects, these results noted that the estimated tendency was highly inconsistent ($Q(3) = 43.865$, $p < 0.00005$). This was not surprising, as the percentage of minorities included in these studies were still fairly low (13-30%), yet more variable than the small percentage included in the above analysis of overwhelmingly white subjects (3-12%). In addition, both sets of analyses are plagued by low power, and as repeatedly indicated, lack of representation of the population as a whole. Taken together, these factors all influence the variability in effect sizes, and ultimately the composite measures.

Following the detection of heterogeneity noted in a meta-analytic procedure, attempts are typically made to decipher reasons for the variability noted in the effect sizes by examining various attributes of the studies. The results of the analyses displayed in Tables 11 and 12, attempted to explain the inconsistency noted, based upon theory. Further efforts were impeded by the small number of studies with sufficient data, and even fewer with uniform reporting of important confounders. This limited a complete model-fitting procedure from being conducted. However, an additional attempt was made to investigate other potential reasons for the inconsistency noted among entries, using a purely statistical approach, namely that of outlier analysis.

Table 16: Helmet Usage Patterns by Race: 4 Entries with Greatest Percentage of Whites (Observational Studies)

race-grp2

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+0.1782	-0.23 / +0.59	+.0889	.0372	-0.335	-2.038
2-Dannenberg-Balt	+0.1999	-0.27 / +0.67	+.0996	.0178	-0.289	-1.228
3-Dannenberg-Mont	+0.6270	+0.37 / +0.88	+.2994	.0000	+0.386	-4.114
4-Fullerton	This case was marked and excluded in this analysis					
5-Cote-HowCo	+0.4170	-0.14 / +0.98	+.2054	.0238	-0.030	-0.010
6-Liller	This case was marked and excluded in this analysis					
7-Rivara-#110	This case was marked and excluded in this analysis					
8-DiGuiseppi-#111	This case was marked and excluded in this analysis					
Overall:	+0.4437	+0.26 / +0.63	+.2166	.0000	0.260	-1.847

```
Note: Q(3)=     4.614; p = 0.2024;
d's are positive for differences in the white-helmeted direction.
effect sizes corrected for bias.
      sums are: TWD = 49.13281  TWDS = 26.41203  TW = 110.743
 Largest outlier is Dannenberg-MontgCo
```

```
Qw( 7 ) =     4.614; p = 0.2024;
     sums are: TWD = 49.13281 ; TWDS = 26.41203 ; TW = 110.743 .
     Dev.= deviation of d from the mean d excluding d.
     The marginal for Dev. is the average absolute deviation.
     Homo.= amount of reduction to Qw if effect size removed.
     The marginal for Homo. is average reduction per effect size.
     This table was created using DSTAT 1.11 on 09-25-1997 at 11:37:17,
     and these data were written to OUTPUT.DST.  The raw effect sizes
     are stored in the file RACE-G2.DAT.
```

End-of-Output

Outlier analysis was performed using DSTAT. Recall that this procedure selects studies in a step-wise fashion that results in the greatest reduction in the Q statistic. Table 18 presents the results of the step-wise procedure that rendered this set of effect sizes consistent. Noticeably, two effect size estimates, Dannenberg et al. (1993) - Montgomery County data, and Rivara et al. (1994) were removed to yield a nonsignificant Q statistic (Q(5) = 7.432, p = 0.1905). Interestingly, these two studies represent approximately the mean percentage of whites among each of the subsets of 4 integrated entries in the analyses presented in Tables 16 and 17 above, respectively.

Table 17: Helmet Usage Patterns by Race: 4 Entries with Highest Percentage of Minorities (Observational Studies)

Race-grp2

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	This case was marked and excluded in this analysis					
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Fullerton	+0.7823	+0.30 / +1.26	+.3669	.0003	+0.566	-5.339
5-Cote-HowCo	This case was marked and excluded in this analysis					
6-Liller	+0.0371	-0.29 / +0.36	+.0186	.7423	-0.188	-1.261
7-Rivara-#110	+0.7868	+0.60 / +0.97	+.3664	.0000	+0.599	-37.079
8-DiGuiseppi-#111	+0.1851	+0.14 / +0.23	+.0921	.0000	-0.434	-28.008
Overall:	+0.2214	+0.18 / +0.27	+.1100	.0000	0.447	-17.921

```
Note: Q(3)=    43.865; p = 0.0000;
d's are positive for differences in the white-helmeted direction.
effect sizes corrected for bias.
      sums are: TWD = 429.4514  TWDS = 138.9593  TW = 1939.425
 Largest outlier is Rivara-#110

Qw( 7 ) =    43.865; p = 0.0000;
     sums are: TWD = 429.4514 ; TWDS = 138.9593 ; TW = 1939.425 .
     Dev.= deviation of d from the mean d excluding d.
     The marginal for Dev. is the average absolute deviation.
     Homo.= amount of reduction to Qw if effect size removed.
     The marginal for Homo. is average reduction per effect size.
     This table was created using DSTAT 1.11 on 09-25-1997 at 11:38:33,
     and these data were written to OUTPUT.DST.  The raw effect sizes
     are stored in the file RACE-G2.DAT.

End-of-Output
```

Moreover, colleagues of both DiGuiseppi and associates (1989) and Rivara and associates (1994) indirectly addressed the issue of the potential influence both SES and race have on the results noted in the data accessed by researchers associated with the Harborview Injury Prevention Center in Seattle, Washington - the center both DiGuiseppi and Rivara were affiliated with. Both of these researchers reportedly accessed the same HMO data and patient population for their studies. DiGuiseppi and associates (1989) formally addressed the issue of SES in their study, and provided median household incomes for the tertiles in the selected city communities (Seattle and Portland). In contrast, Rivara and associates (1994) did not comment on the SES of the Seattle community in their manuscript. However, Rivara, as co-author of another manuscript from the same Center, and utilizing the same sample population did, but the information provided was contradictory (Thompson et al. 1989). Initially the authors of the earlier manuscript stated, "Group Health Cooperative membership was used because its automated files were available for subject selection, it was demographically similar to the surrounding population, and it accounted for 42.3% of the case patients as well" (Thompson, Rivara, & Thompson 1989, p.1362). Shortly after this statement, the authors contradicted themselves, commenting, "Group Health Cooperative members were more highly educated; 67 percent had more than a high school education, as compared with 47 percent of the metropolitan population" (Thompson, Rivara, & Thompson 1989, p. 1362). Because education is positively associated with income, which is negatively associated with many minority groups, it would appear that the selected HMO population is not "similar to the surrounding Seattle population." Furthermore, rationally, a greater percentage of members of lower income households are likely to be unemployed, and therefore not members of a HMO. Thus, even among studies that did consider the impact race places in bicycle helmet usage patterns, the selected sample populations were, recognizably, plagued by lack of representativeness.

Table 18: Stepwise Removal of Outliers for Helmet versus Non-helmet Usage Data by Race

race-grp2

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+0.1782	-0.23 / +0.59	+.0889	.0372	-0.011	-0.003
2-Dannenberg-Balt	+0.1999	-0.27 / +0.67	+.0996	.0178	+0.011	-0.002
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Fullerton	+0.7823	+0.30 / +1.26	+.3669	.0003	+0.599	-5.973
5-Cote-HowCo	+0.4170	-0.14 / +0.98	+.2054	.0238	+0.229	-0.641
6-Liller	+0.0371	-0.29 / +0.36	+.0186	.7423	-0.155	-0.858
7-Rivara-#110	This case was marked and excluded in this analysis					
8-DiGuiseppi-#111	+0.1851	+0.14 / +0.23	+.0921	.0000	-0.072	-0.516
Overall:	+0.1891	+0.14 / +0.23	+.0941	.0000	0.179	-1.332

```
Note: Q(5)=     7.432; p = 0.1905;
d's are positive for differences in the white-helmeted direction.
effect sizes corrected for bias.
      sums are: TWD = 356.0167  TWDS = 74.75842  TW = 1882.584
 Largest outlier is Fullerton
```

```
Qw( 7 ) =      7.432; p = 0.1905;
      sums are: TWD = 356.0167 ; TWDS = 74.75842 ; TW = 1882.584 .
      Dev.= deviation of d from the mean d excluding d.
      The marginal for Dev. is the average absolute deviation.
      Homo.= amount of reduction to Qw if effect size removed.
      The marginal for Homo. is average reduction per effect size.
      This table was created using DSTAT 1.11 on 08-12-1997 at 22:05:19,
      and these data were written to OUTPUT.DST.  The raw effect sizes
      are stored in the file RACE-G2.DAT.
```

End-of-Output

Intervention/Campaign Evaluation

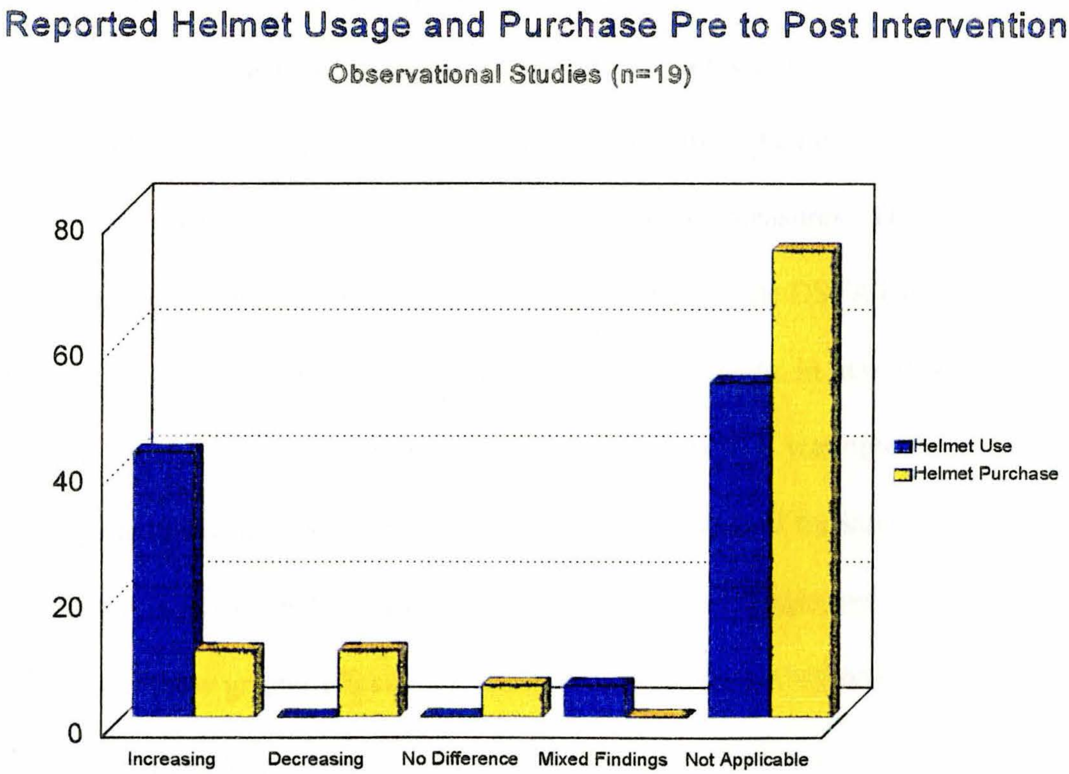
Most investigators elected to administer, or mail a survey, rather than directly observe cyclists, in order to obtain information on cycling habits, helmet usage patterns, and bicycle-related injuries (42%) (Refer to Table 1). Interestingly, although the primary outcome of interest for the majority of investigators was helmet usage (n=8, 42%), or both helmet usage and helmet purchase collectively (n=7, 37%), most researchers failed to survey respondents, or report findings, on important issues. Relevant factors such as reasons for not wearing or owning a bicycle helmet, and type of helmet, were two items not addressed by most investigators (68% and 84%, respectively). This was an unexpected finding, in lieu of the meaningful information that such questions could provide.

Among the investigators seeking to implement and/or evaluate the success of a bicycle helmet and safety intervention, combined education and community campaigns were most popular, and reportedly, consistently beneficial (n=5, 26%). Legislation only was the primary strategy of interest for three researchers (16%), all of whom reported on the success of legislation in Howard County, Maryland, in comparison to two surrounding counties without similar legislation. All three investigators reported a uniform increase in helmet usage among children. However, when compared with the other two counties, older children in Howard County were reported to wear bicycle helmets less frequently than some of the younger children in the two counties without helmet legislation (Dannenberg et al. 1993). Thus, helmet compliance may be more of a function of parental education and restriction than legislation. Moreover, perceived independence may be just as important a factor among teenagers, as it is among motorcycle helmet opponents.

The importance of multi-faceted coalitions continued to be demonstrated by the less effective single intervention studies. Macknin and Medendorp (1994) found that "the association was stronger than that found with legislation only" in reference to legislation combined with education (p. 255). Conversely, Pendergrast and associates (1992) reported the failure of an educational campaign promoting bicycle helmet usage. However, the lack of total commitment on the part of school's PTA to implement a comprehensive campaign, likely contributed to its failure. In comparison to the less successful single interventions of legislation and education noted above, respectively, Schneider and associates (1993) reported mixed results for a primarily community focused campaign, aimed at increasing helmet ownership. Moreover, they attributed some of the noted success found to the SES of the study sample. More specifically they stated, "Generalization of these findings is limited by the high socioeconomic status of the study participants" (p. 281). Lastly, Weiss (1992) revealed that global media education and support of bicycle helmets, can increase helmet usage in communities without the implementation of any specific campaign.

Helmet use, or purchase, was measured pre to post-intervention, as appropriate (53% of studies), with varying levels of success. Expectedly, helmet usage reportedly increased significantly by all (n=8) but one study utilizing the pre to post intervention design (See Figure 12). In contrast, documented or reported helmet purchases fluctuated. An equal number of studies exhibited an increase in bicycle helmet purchases, as did those who noted a decrease in bicycle helmet purchases (n=2, 10.5% for each, respectively), with one study registering no difference post intervention (See Figure 12). Alternately, most studies found an increase in the reported intention of cyclists to use a bicycle helmet (n=7, 37%), and overall, noted an increase in helmet usage practices (n=9, 47%).

Figure 12:



Meta-analyses were performed on the observational studies that assessed helmet usage as an outcome variable. Effect size estimates for each study were adjusted for sample size, given that studies with larger sample sizes typically provide more accurate estimates of the population effect size. If a study reported on more than one type of intervention, each intervention was treated as independent, and was entered separately into the analysis. Studies not evaluating any specific type of intervention, but rather assessed the prevalence of helmet use among cyclists via roadside observation and interviews, or self report surveys, were also included. It was felt that these studies would provide an estimate of the effect of global media advertisements on increasing helmet usage. Frequency information was reported for all studies, and thus were the statistic entered into the DSTAT proportions and frequency program for effect size calculation. Effect size estimates for studies utilizing a pre to post-test design, were calculated by subtracting the pre-test frequency score from the post-test frequency score, and dividing by the sample size of the smaller of the two measures. This procedure was chosen due to the limitations in both the reported data and the DSTAT program. In addition, it was felt to provide the most conservative estimate, in lieu of other potential options. Lastly, due to the varying lengths of study design, it was opted to select the last recorded measure, in studies with multiple assessments of the interventions. Although it is recognized that studies implemented over a longer period of time may be expected to show greater effects, it was noted that researchers referencing studies, typically evaluated the success of a given strategy by referencing the largest effect shown, and disregarded the period of investigation. Therefore, it was this information that was used to determine whether or not a campaign was perceived to be effective by this body of researchers.

Table 19 displays the results of the analysis including all types of interventions (no intervention, legislation only, education only, and the joint approach of education and community). As indicated in Table 19, the mean weighted effect size measure for all forms of interventions combined was $d = -0.9575$, with a corresponding 95% confidence interval of -0.99 to -0.93. Therefore, the integration of all kinds of bicycle helmet promotional strategies, both global media promotion and specific types of interventions, resulted in a significant negative difference between helmet users and non-users, thereby favoring non-helmet usage. Furthermore, the Pearson Product Moment Correlation (PMMR), between differences in helmet users and bicycle helmet intervention strategies revealed a negative correlation ($r = -0.4318$, $p = 0.00005$). Thus, collectively, the various promotional campaigns appeared to have inhibited, rather than facilitated helmet usage. However, this tendency was highly inconsistent ($Q(28) = 12322.062$, $p = 0.00005$). In lieu of these findings, this author attempted to explain some of the variability in effect sizes by examining various sub-groups of this data set. The various sub-groups analyzed are presented in Table 20. The complete DSTAT output associated with all the analyses are presented in Appendix G, for those interested in more detailed information.

Table 19: Global and Specific Intervention Strategies' Effect on Helmet Usage (Observational/Survey Studies)

Intervention-Helmet Use Data Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+2.169	%-1064.271
2-Dannenberg-Balt	-0.0389	-0.16 / +0.08	-.0195	.5131	+0.978	-253.685
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+1.118	-534.904
4-Wasserman	-3.1551	-3.34 / -2.97	-.8450	.0000	-2.253	-569.164
5-DiGuiseppi	+0.2431	+0.06 / +0.43	+.1211	.0104	+1.230	-163.427
6-Kimmel&Nagel	-5.9137	-6.31 / -5.52	-.9476	.0000	-4.983	-613.750
7-Fullerton&Becke	+0.1896	-0.31 / +0.69	+.0968	.4506	+1.151	-20.372
8-Ruch-Ross&O'Con	-1.4139	-1.50 / -1.32	-.5775	.0000	-0.507	-108.735
9-Weiss-HighSchoo	+8.0350	+7.03 / +9.04	+.9710	.0000	+9.000	-307.839
10-Weiss-College-N	+5.1733	+4.70 / +5.65	+.9333	.0000	+6.154	-651.147
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-4.853	-415.622
12-Pendergrast-Lit	+19.6599	+18.68 /+20.64	+.9949	.0000	+20.635	%-1686.610
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.608	-9.221
14-Cote-BaltimoreC	+2.0898	+1.52 / +2.66	+.7297	.0000	+3.055	-111.413
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.166	-107.666
16-Dannenberg2-Bal	-2.6096	-2.72 / -2.50	-.7939	.0000	-1.780	-986.271
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	+0.315	-47.324
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-1.538	-686.601
19-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+1.823	-895.399
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	+0.441	-25.311
21-Macknin&Mendend	-1.6688	-1.88 / -1.46	-.6419	.0000	-0.724	-43.767
22-Macknin&Mendend	-1.3812	-1.54 / -1.22	-.5691	.0000	-0.437	-27.079
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+3.067	-392.946
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.102	-319.385
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.193	-2.219
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+0.604	-116.088
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.461	-71.685
28-DiGuiseppi-Port	-5.9948	-6.20 / -5.79	-.9487	.0000	-5.143	%-2480.949
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-1.029	-9.906
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-1.089	-13.979
Overall:	-0.9575	-0.99 / -0.93	-.4318	.0000	2.720	-424.558

Note: Q(29)= 12321.122; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-4476.972 TWDS = 16607.99 TW = 4675.502
Largest outlier is DiGuiseppi-Portland

Qw(29) = 12321.122; p = 0.0000;
sums are: TWD =-4476.972 ; TWDS = 16607.99 ; TW = 4675.502 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 14:37:22,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table 20: Various Sub-group Analyses of Global and Specific Interventions Strategies' Effect on Helmet Usage (Observational/Survey Studies)

Type of Study	**d**	**95% CI for d**	**r corresponding to d**	**p-value for r**	**Q-statistic and p-value**
Only Legislation only entries included (Appendix G-1)	0.0268	-0.03, 0.08	0.0134	0.3305	Q(4)=740.147 p < 0.00005
Only Legislation only & Joint Educ. and Comm. entries (Appendix G-2)	-0.3854	-0.43, -0.34	-0.1892	0.0000	Q(9)=2115.381 p < 0.00005
Only Legislation only & Education only entries (Appendix G-3)	-0.4279	-0.47, -0.38	-0.2092	0.0000	Q(9)=3000.073 p < 0.00005
All interventions entries with no intervention entries excluded (Appendix G-4)	-0.5864	-0.62, -0.55	-0.2813	0.0000	Q(14)=4052.075 p < 0.00005
All interventions except for education only entries (Appendix G-5)	-0.9282	-0.96, -0.90	-0.4210	0.0000	Q(24)=10665.445 p < 0.0005
Only Joint Educ. & Comm. entries included (Appendix G-6)	-0.9557	-1.02, -0.89	-0.4311	0.0000	Q(4)=879.599 p < 0.00005

Type of Study	d	95% CI for d	r corresponding to d	p-value for r	Q-statistic and p-value
All interventions except for joint education & community entries (Appendix G-7)	-0.9580	-0.99, -0.93	-0.4320	0.0000	Q(24)=11441.516 p < 0.00005
Only Education only & Joint Educ. and Comm. entries (Appendix G-8)	-1.0238	-1.07, -0.98	-0.4557	0.0000	Q(9)=2528.443 p < 0.00005
Only Education only entries included (Appendix G-9)	-1.0921	-1.16, -1.02	-0.4793	0.0000	Q(4)=1637.186 p < 0.00005
All interventions except for Legislation only entries (Appendix G-10)	-1.3066	-1.34, -1.27	-0.5469	0.0000	Q(24)=9974.590 p < 0.00005
All interventions except for both legislation only and education only entries (Appendix G-11)	-1.3753	-1.41, -1.34	-0.5666	0.0000	Q(19)=8286.510 p < 0.00005
No intervention studies only data (Appendix G-12)	-1.5900	-1.64, -1.54	-0.6223	0.0000	Q(14)=7171.436 p < 0.00005

Table 21: Various Sub-group Analyses of Specific Interventions Strategies' Effect on Helmet Usage: Effect if Removal of Confounded Legislative Entry (Beachwood) (Observational/Survey Studies)

Type of Study	**d**	**95% CI for d**	**r corresponding to d**	**p-value for r**	**Q-statistic and p-value**
Only Legislation only entries included (Appendix H-1)	*-0.1959*	*-0.26, 0.13*	*-0.0975*	*0.0000*	*Q(3)=542.168 p < 0.00005*
Only Legislation only & Joint Educ. and Comm. entries (Appendix H-2)	*-0.5649*	*-0.61, -0.52*	*-0.2718*	*0.0000*	*Q(8)=1684.418 p < 0.00005*
All interventions entries with no intervention entries excluded (Appendix G-4)	-0.5864	-0.62, -0.55	-0.2813	0.0000	Q(14)=4052.075 p < 0.00005
Only Legislation only & Education only entries (Appendix H-3)	*-0.6190*	*-0.67, -0.57*	*-0.2957*	*0.0000*	*Q(8)=2534.638 p < 0.00005*
All interventions except for education only entries (Appendix G-5)	-0.9282	-0.96, -0.90	-0.4210	0.0000	Q(24)=10665.445 p < 0.0005
Only Joint Educ. & Comm. entries included (Appendix G-6)	-0.9557	-1.02, -0.89	-0.4311	0.0000	Q(4)=879.599 p < 0.00005

Type of Study	d	95% CI for d	r corresponding to d	p-value for r	Q-statistic and p-value
All interventions except for joint education & community entries (Appendix G-7)	-0.9580	-0.99, -0.93	-0.4320	0.0000	Q(24)=11441.516 p < 0.00005
Only Education only & Joint Educ. and Comm. entries (Appendix G-8)	-1.0230	-1.07, -0.98	-0.4554	0.0000	Q(9)=2532.661 p < 0.00005
Only Education only entries included (Appendix G-9)	-1.0921	-1.16, -1.02	-0.4793	0.0000	Q(4)=1637.186 p < 0.00005
All interventions except for Legislation only entries (Appendix G-10)	-1.3066	-1.34, -1.27	-0.5469	0.0000	Q(24)=9974.590 p < 0.00005
All interventions except for both legislation only and education only entries (Appendix G-11)	-1.3753	-1.41, -1.34	-0.5666	0.0000	Q(19)=8286.510 p < 0.00005
No intervention studies only data (Appendix G-12)	-1.5900	-1.64, -1.54	-0.6223	0.0000	Q(14)=7171.436 p < 0.00005

This author acknowledges that conducting multiple analyses on the same data set increases the likelihood of a Type I error. However, because this was an exploratory analysis that attempted to detect potential sources of variability in the overall data set, and not a confirmatory or more definitive analysis, it was overlooked. In addition, this author postulated that no intervention studies may have had a negative impact on the composite effect measure presented above, that would be removed if only those studies with a specific intervention strategy were included. In addition, one effect size estimate involved overlapping, and un-separatable, interventions. This confounded intervention was in the legislation only sub-group. It was a joint legislative and education approach extricated from Macknin and Mendendorp's study (1994) referencing the Beachwood community in Ohio. Analyses will also be performed excluding this study, reducing the number of studies in this category to 4, to see if this entry had a substantial impact on the findings of associated analyses.

It is apparent from Table 20 that none of the current measures appear to have a significant positive impact on increasing helmet usage among cyclists. Of the four types of interventions reviewed, namely global media promotion (or no direct intervention), legislation, education and the joint education and community approach, only legislation produced a positive mean weighted effect size (d = 0.0268, 95% CI = -0.03 to 0.08) in the direction of helmeted cyclists. However, both the 95% CI inclusive of zero, and the correlation coefficient and associated p-value indicate that overall, no relationship exists between helmet usage and legislation. Although, the contribution of legislation to increasing bicycle helmet usage is suggested by its presence among the lowest three composite effect measures in the sub-group analyses performed (d = 0.0268 (legislation only), -0.3854 (legislation only and joint education and community approach), -0.4279 (legislation only and education only approaches combined)). Nonetheless, not only was no significant relationship found between helmet usage and mandated compulsory helmet usage, but a significant lack of homogeneity was noted. This implies that the individual effect size estimates differed significantly from one another in magnitude, direction, or possibly both. This is surprising considering 3/5 of the entries referenced the same region, specifically Howard County, Maryland. Thus, inconsistency in effect outcome appears to prevail even within the same region -- a region that had been pronounced as a landmark area of the country for the use of legislation to increase helmet usage.

The removal of the confounded entry from the legislation only group mentioned above (legislation plus education approach), removed the highest positive effect size estimate (thus favoring helmet usage), thereby reducing the overall effect from a non-significant positive composite effect size measure, to a significant negative effect size measure ($d = -0.1959$, 95% CI = -0.26 to -0.13), while increasing the absolute value of the correlation coefficient from 0.0134 ($p = 0.3305$) to -0.0975 ($p < 0.00005$). Even more troublesome, was that heterogeneity continued to prevail , even when 3 of 4 measures were referencing the same program that was implemented in the same area of the country - Howard County, Maryland.

Examination of the remainder of the sub-group of entries revealed that no direct intervention strategies, or global media promotion, appeared to have the least effect on increasing helmet usage ($d = -1.5900$, 95% CI = -1.64 to -1.54). In comparison, although all specific forms of interventions combined (legislation only, education only, and joint education and community approaches), resulted in a significant negative association between helmet usage and their integrated effect (d = -0.5864, 95% CI = -0.622 to -0.55, r = -0.2813 and associated p-value < 0.00005), the magnitude of the negative association was less.

Not surprising, education alone appeared to be the least effective single approach to increasing helmet usage among cyclists (d = -1.0921, 95% CI = -1.16 to -1.02). Aside from the several confounding factors mentioned repeatedly throughout this manuscript that were insufficiently addressed in the study designs reported by investigators in the area of research (i.e., SES, race, highest education attained by primary household member), other non-systematic factors could have impacted educational promotions and campaigns. Factors such as teacher proficiency, type and style of educational program implemented, acceptability of program by faculty and parents, etc., may all have contributed to the inability of these studies to have more of a positive influence on helmet usage.

The joint approach of education and community had an impact that faired better than education alone, and slightly less than legislation alone (d = -0.9557, 95% CI = -1.02 to -0.89). Although a negative association between this approach and helmet usage has been found, its impact was nearly identical to that previously noted following the integration of all types of strategies, including global media promotion (d = -0.9575, 95% CI = -0.99 to -0.93).

As with all other analyses, the analyses seeking to evaluate the effect of the various forms of interventions on increasing helmet usage among cyclists, were all troubled by lack of homogeneity. This author was unable to detect the entries' qualities that may have contributed to the heterogeneity noted, in the variety of sub-group analyses performed. Further study qualities were not able to be investigated due to the inconsistency in reporting among this group of researchers. However, it is important to note that the sub-group analyses performed were also plagued by low statistical power, due to the small number of studies forming each sub-group. Therefore, any inferences gathered from these analyses should be done so with prudence.

An analysis of variance procedure was also performed using the d values, or effect size estimates for each study, to determine whether type of intervention influences helmet usage. The dependent variable was helmet usage, while the independent variable was the four campaign strategies undertaken, namely, no direct intervention or global media promotional campaigns, legislation only, education only, and the joint education and community approach. Three different analysis of variance procedures were performed. The first procedure, conducted as stated above, was done including the confounded Beachwood entry in the legislative only group. The second procedure was identical to the first, with the exclusion of the Beachwood entry, while the final procedure compared only two groups, the no intervention, or global media promotion group, and all other strategies combined.

The findings of the above analysis of variance (ANOVA) procedures are presented in Tables 17-19. The results reveal that the test statistic exceeds the critical value in all three procedures, so we fail to reject the null hypothesis, and conclude that the type of interventions are not related to the mean differences in helmet usage. Accordingly, the Beachwood entry did not influence the outcome (Table 23). Note however, that all three analyses also violated Levine's test of homogeneity of variance. In other words, for each intervention, the conditional distribution of the residual errors did not have the same variance. Thus, the problems of heterogeneity found in the meta-analysis procedures continued to persist in the ANOVA procedures. Noticeably, the no direct intervention group and the education only groups revealed the largest standard errors (1.0101, 4.3360), respectively (See Table 22), thereby reflecting the poor predictive ability of these two intervention strategies. Variance stabilizing formulas were not applied to this data set, as transforming the data was not advisable. Furthermore, multiple comparisons procedures were also not performed due to both the presence of heterogeneity of variances and a nonsignificant overall F test.

Table 22: Analysis of Variance Summary Results Table: Four Types of Interventions Compared (Beachwood Entry Included in Group 2)

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	45.3985	15.1328	.6484	.5911
Within Groups	26	606.8148	23.3390		
Total	29	652.2132			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	15	-.9521	3.9123	1.0101	-3.1186	TO	1.2145
Grp 2	5	.0586	.8105	.3625	-.9477	TO	1.0649
Grp 3	5	2.4432	9.6957	4.3360	-9.5954	TO	14.4817
Grp 4	5	-.7750	1.8628	.8331	-3.0880	TO	1.5380
Total	30	-.1882	4.7424	.8658	-1.9591	TO	1.5826

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
4.2731	3	26	.014

*Group 1: No direct intervention, Group 2: Legislation only, Group 3: Education only, Group 4: Joint education and community approach.

Table 23: Analysis of Variance Summary Results Table: Four Types of Interventions Compared (Beachwood Entry Excluded from Group 2)

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	45.0847	15.0282	.6198	.6088
Within Groups	25	606.2115	24.2485		
Total	28	651.2962			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	15	-.9521	3.9123	1.0101	-3.1186	TO	1.2145
Grp 2	4	-.1151	.8214	.4107	-1.4222	TO	1.1920
Grp 3	5	2.4432	9.6957	4.3360	-9.5954	TO	14.4817
Grp 4	5	-.7750	1.8628	.8331	-3.0880	TO	1.5380
Total	29	-.2207	4.8229	.8956	-2.0552	TO	1.6138

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.9820	3	25	.019

*Group 1: No direct intervention, Group 2: Legislation only (excluding Beachwood entry), Group 3: Education only, Group 4: Joint education and community approach.

Table 24: Analysis of Variance Summary Results Table:
No Direct Intervention versus All Specific Forms of Interventions Combined

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	17.5028	17.5028	.7721	.3870
Within Groups	28	634.7104	22.6682		
Total	29	652.2132			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	15	-.9521	3.9123	1.0101	-3.1186	TO	1.2145
Grp 2	15	.5756	5.4800	1.4149	-2.4591	TO	3.6103
Total	30	-.1882	4.7424	.8658	-1.9591	TO	1.5826

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0001	1	28	.991

*Group 1: No direct intervention, Group 2: All specific forms of interventions combined.

These findings reveal that none of the current measures, or combinations of these measures, are effective in significantly increasing helmet usage of cyclists. However, of these measures, legislation appears most effective, albeit not significant. The failure of the legislative approach (both with and without the confounded Beachwood entry), may be due in part to a variety of reasons, including:

1.) Small number of entries available for the meta-analysis (n = 5 or 4).

2.) The inability of police to enforce the bicycle helmet legislations already in place, due to other more grievous issues.

3.) The perception of parents, children, teenagers, health care personnel, educators, and cyclists, that bicycle helmet usage is not an important, or as important as other more pressing issues, such as food, rent, violence, or drugs.

4.) Peer pressure, rebellious behavior, or the perception that such mandates are infringing upon one's individual rights, may also contribute to non-compliance in regions of the country where helmet laws do exist.

5.) The best solution to the problem has not yet been identified by injury prevention researchers, health care professionals, and educators working in this field.

Thus, although professionals from various disciplines have joined forces to find a means to reduce the number of bicycle-related injuries and fatalities sustained each year by cyclists of all ages, none of the current efforts appear to provide a definitive solution to the problem. Methodological flaws and biases may have contributed to this finding. However, until better research is conducted, or reported, that supports the passage of compulsory bicycle helmet legislation in the United States, this comprehensive review of the literature did not find any justification for its enactment. Furthermore, this author recommends the conductance of research among population members that were previously excluded in the majority of published research (i.e., minorities and lower income families), prior to passage of any additional legislation.

The rationale for this decisive statement is simple. Many of the mandates currently in place resulted from an unfortunate, often deadly, incident occurring in a community; i.e., the death of a nonhelmeted cyclist, frequently a child. Parents, relatives and friends suddenly became advocates of the need for compulsory bicycle helmet legislation. These vociferous community members gained the support of some health care professionals and educators, and thus put into motion the political agenda-setting process. However, what this research reveals is that in the emotional drive, the quality of research suffered as evident by the many methodological problems noted throughout this manuscript, legislation was hastily passed without any definitive supporting evidence, and most importantly, some children were unnecessarily deprived of a recreational pastime enjoyed by probably all those involved in the enactment of compulsory helmet legislation, merely, because their parents were unable to afford a bicycle helmet, and the potential fine levied upon them if their child was caught riding their bicycle without one.

Summary

Three important findings were uncovered in the observational literature. First, the striking under-sampling of minorities and lower income families, was overwhelmingly apparent in the bicycle-related literature. Secondly, whites were more likely than non-whites to wear a bicycle helmet. And lastly, none of the strategies currently in place to increase bicycle helmet usage, were found to have a significant positive effect, including legislation. Plausible explanations for the first, and possibly the second inference, are many including, but not limited to the following:

1.) Unwillingness on the part of investigators to go to more deprived areas for one of many reasons,

2.) Inconvenience, i.e., lack of proximity to the research center, hospital or university conducting the study,

3.) Obtaining funds to support a program by members of more affluent communities with the enticement that the program would be implemented in their community,

4.) Selection of middle and upper-middle class communities under the premise that the program may be able to be implemented and evaluated in a shorter period of time, due to the generally higher educational level, and greater socioeconomic status of those residing in the communities,

5.) In contrast to the above, awareness that lower income neighborhoods may not only require more substantial helmet discounts, or free helmets, but also longer educational phases.

The effect of bias in favor of middle and upper-middle class subjects was both clearly discernable, as noted throughout this manuscript, and likely subtle as well. The subtle impact relates to the entire political and research process surrounding the issue of compulsory helmet legislation. Charles Redenius, author of The American Republic: Politics, Institutions, and Policies (1987) comments,

"Issues of concern to higher socioeconomic groups are more likely to reach the policy agenda. These people are more likely than people of lower socioeconomic status to be politically active, members of interest groups, understand the political system, and have the time and access to information necessary to maneuver an issue onto the policy agenda. Moreover, policy makers are more inclined to consider issues raised by the higher-status citizens because they tend to have high-status backgrounds themselves and share the concerns and views of this sector of the population" (p. 244).

The reality of Redenius' (1987) statement is apparent in the body of research reviewed here. The importance of compulsory bicycle helmet legislation and the affordability of bicycle helmets are likely shaped, in some form, by the socioeconomic status of those queried (typically relates to educational level, profession, location of residence). Lower status families likely have more demanding issues such as poverty, violence, gangs, drugs, and other forms of animosities affecting their daily lives, that middle and upper status families do not even fathom. Furthermore, it seems only logical, that prior to the passage of a county or state mandate that requires people to purchase an item in order to comply, that consideration would not only be given to the effectiveness of the mandate, but also to the feasibility of everyone complying. Should future research enable a definitive conclusion in favor of compulsory helmet legislation to be reached, subsidies similar to infant car seats, baby formula or food, vaccinations, and the like, should also be considered for child bicycle helmets for those who cannot afford them. After all, it is the children who are suffering, not only from bicycle injuries, but also from adults' seemingly hasty resolution to a more complex problem.

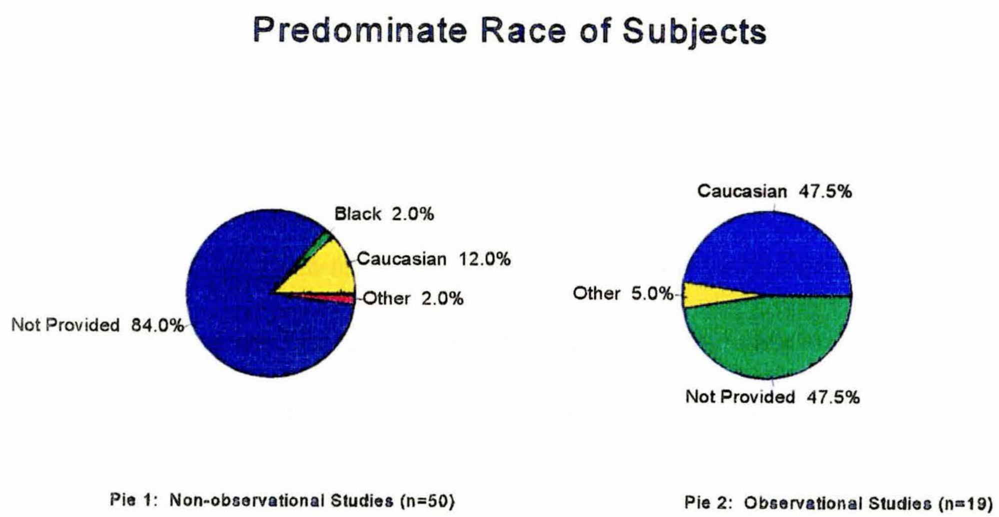
It is not the intention of this author to trivialize the issue of bicycle helmets. Rather, it is the aim of this author to present the findings of a comprehensive review of the literature, inform the reader of the findings, and suggest possible explanations for what was found. However, as a health care professional and researcher who believes in quality research that is conducted and interpreted both morally and ethically, this author feels an obligation to address all issues impacting the findings of the present study, including some that may be more politically and medically volatile.

Comprehensive Summary

Evaluation of Study Design and Methodology

The lack of uniformity by both observational and non-observational study researchers prohibited a definitive examination into whether bicycle helmets are equally beneficial for all age groups. The sundry of age categories by all researchers raises the question as to whether age categories were selected to best illustrate the author's perspective, rather than the study's general outcome. Not unlike the problems encountered with the age variable, race was similarly plagued with inconsistencies. The failure of some studies to include adequate minority samples, or sufficiently report racial data as it pertains to helmet usage practices, prohibited more formal model testing procedures to help distinguish between consistent and inconsistent helmet usage patterns (See Figure 13). Moreover, it precluded the examination of the potential relationship between helmet usage, race, SES, and educational level; factors important in the affordability and perceived importance of helmets. In addition, lack of assessment, or reporting, of data related to important confounding variables impeded the measurement of the role such variable may have played in the substantial lack of homogeneity noted throughout these analyses.

Figure 13:



The ability to determine whether certain variables are moderator variables is an important consideration in the presence of heterogeneity. The reason for this is that when heterogeneity is found, meta-analysts seek to identify variables that account for the nugatory variance. Hunter and Schmidt (1990) recommend that, "studies be subgrouped based on the moderator hypothesis, and the means of the subgroup meta-analysis can be tested for statistically significant differences . . . . statistical power in meta-analysis is much higher for this approach to detecting moderators" (p. 415). This is a common approach to identify the potential source of heterogeneity when it is detected. However, the consistent lack of reporting of important confounders, and the notable sampling error, precluded the ability to perform both more advanced outlier analyses and model testing procedures.

The small number of studies that attempted to incorporate data associated with recognized confounder variables are reflected in Table 1. Review of this table illustrates the impact that non-uniform documentation, and lack of reporting of relevant variables, had on this meta-analysis. Discernibly, it seriously curtailed the number of testable hypotheses, and thus, the ability to draw definitive conclusions from this meta-analysis. Hunter and Schmidt (1990) address the issue of sample size and ultimately, statistical power in their comment, "eight is a small number of studies for a meta-analysis" (p. 415). Unfortunately, not even eight studies provided sufficient data, or any data, on many of the meaningful confounder variables (See Table 1).

As with all research, it is generally accepted that meta-analysis will include some studies that are poorly designed, have poor data, or have used inappropriate statistical techniques. This results in biases or erroneous study effect sizes. Examination of outliers, model testing, and visual displays all help to detect such flaws. Most problematic however, is sampling error - a problem that plagued this literature. In reference to sampling error, Hunter and Schmidt remarked, "Sampling error acts differently from other artifacts in that it is (1) additive and (2) unsystematic. While a confidence interval for the effect size provides an unbiased estimate of potential sampling error for the single study, there is no correction for sampling error at the level of the single study" (p. 263). As such, the portentous role of sampling error uncovered in this body of literature, broaches the path for improvement in this body of literature. Hopefully, a strength of this manuscript will be its ability to impart upon investigators conducting research associated with bicycle-related injuries and helmet usage patterns, areas that have consistently suffered from various biases and errors, but are potentially correctable.

Evaluation of Hypotheses

Four distinct categories of hypotheses were conceived, namely, helmet related, injury related, bicycle safety campaigns/interventions, and significant confounding variables. A series of secondary and tertiary questions were posed in each category that were deemed essential to a factual and reliable answer to one fundamental question, "Is compulsory bicycle helmet legislation warranted?" All secondary and tertiary questions listed in the sub-categories provided below, were believed to either directly or indirectly influence the following two primary questions:

1.) Have bicycle helmets been sufficiently evaluated in samples that are representative of the population of recreational cyclists, and thus the population at large, (i.e., in all races, among all age groups, in all socioeconomic classes, and among all individuals or families with varying educational backgrounds), to warrant mandatory helmet legislation for all cyclists, or just select members of our society?

2.) Has legislation been shown to be the most effective means of significantly increasing bicycle helmet usage, thereby indirectly reducing the number of bicycle-related injuries?

Accordingly, the supplementary hypotheses associated with each category will be addressed first, to provide all necessary information for a complete evaluation of both primary hypotheses, and ultimately the principal question.

Bicycle Related Hypotheses

All interventions aimed at increasing helmet usage, including school-based educational campaigns, community campaigns with or without media involvement, legislative mandates, as well as no direct campaign at all, reported some increase in helmet usage (See Figure 12). Based on reported information, multi-faceted coalitions appeared to have been most successful, with combined educational and community-wide media campaigns, experiencing success in a variety of communities. All studies whose primary aim was to evaluate the success of an intervention were conducted prospectively. No study reported a significant reduction in helmet usage, following the implementation of a specific intervention.

However, the integration of the results of the various interventions using meta-analytic procedures revealed that none of the current interventions that provided sufficient data for the application of synthesizing procedures, namely, legislation, education, joint education and community approaches, and no direct intervention or global media campaigns only, significantly increased helmet usage among cyclists. In lieu of a significant effect, legislation appeared to be the most effective strategy among those evaluated. However, the analyses of legislation only entries were plagued by a variety of sampling and dependency biases, as well as low power (n=4 or 5, depending on analysis).

The use of meta-analytic techniques to evaluate the role of various confounders, namely age, gender, race (non-observational studies), socioeconomic status and highest level of education attained by primary household member, was not possible, due to either the inconsistency in reporting of these measures, or the failure of researchers to address them. In the observational and survey literature, however, race was the only variable with a number of entries that reported directional helmet usage information. Results of the corresponding meta-analysis using the observational/survey literature, revealed that whites were more likely than non-whites to wear a bicycle helmet. This was not surprising, considering the apparent exclusion of minorities and minority communities, from many of the bicycle helmet campaigns (See Figure 13).

Injury Related Hypotheses

The protective effect of bicycle helmets was often the focus of non-observational, rather than observational, research studies. However, a comprehensive meta-analytic evaluation of the protective benefit of bicycle helmets on reducing the number and severity of bicycle-related injuries, particularly head injuries, was not possible. The reason for this was that an overwhelming majority of researchers did not provide helmet/non-helmet injury comparisons (See Table 1), thereby prohibiting the integration and evaluation of effect size estimates, due to a lack of sufficient number of studies reporting adequate data. Thus, effect size estimate comparisons by type of injury sustained (neurological, orthopedic, etc.) were not performed. Similarly, lack of data precluded the assessment of the influence of age, gender, and riding experience, on the number and type of injuries incurred by cyclists.

In the analysis of the composite effect size estimates assessing helmet usage among injured cyclists, entries emphasizing bicycle-related head injuries ($d = -7.1435$, 95% CI = -7.29 to -6.99), in comparison to entries reporting bicycle-related injuries in general ($d = -2.0275$, 95% CI = -2.27 to -2.15), revealed that the magnitude of non-helmet usage was greater for cyclists sustaining head injuries. However, an analysis of variance procedure, using the effect size estimates obtained in the meta-analytic procedure, found no significant difference in helmet usage between bicyclists who had sustained head injuries, and those who had incurred an injury in general ($F = 1.5392$, $p = 0.2394$). Thus, although a directional difference in the magnitude of the calculated effect size estimates between cyclists incurring a head injury and those sustaining any form of injury, appeared to be visibly apparent, ANOVA procedures revealed that the difference was not significant.

The impact of bicycle helmet campaigns on minimizing the occurrence of head injuries sustained by cyclists, could only be assessed through the examination of the directional differences in the magnitude of the measured effect size estimates. This reason for this was the small number of entries focusing on head injuries that provided data adequate for a meta-analysis (n=4). Although an increase in helmet usage was noted (as evident by a less negative effect size estimate), the trend was not consistent for all four studies. Rather, only for the latest study (1988) and the most recent study, (1995) was an increasing trend noted in the effect size estimate. A fluctuation in helmet usage among head injured cyclists was noted in interim years. Thus, despite the numerous interventions promoted from 1988 through 1995, that were aimed at reducing the number of bicycle-related head injuries by increasing helmet usage, including global media campaigns, and specific tactics, such as legislation, education, and joint education and community approaches, a simultaneous consistent reduction in the effect size estimates was not noted.

Comparison of type of data, namely general hospital data and fatality data, by the kinds of injury sustained by helmeted and non-helmeted cyclists was not possible. Too few studies reported directional data for comparisons to be made by injury type. However, analysis of the data did reveal more negative effect size estimates in relation to helmet usage, among head injured study entries, in comparison to studies providing information on bicycle-related injuries in general. However, further analysis revealed that the magnitude of the difference was not significantly different, or could be attributed to chance. Thus, although examination of the effect size estimates calculated for helmet usage by type of study (general versus head focus) revealed that the aggregate of injured cyclists appeared unlikely to be wearing a helmet at the time of their injury, with studies focusing on head injured cyclists seeming to find an even lower probability that cyclists were wearing a helmet at the time of their accident, the noted difference in helmet usage was found to be insignificant.

Examination of the data by collision type, that is bicycle-motor vehicle collisions versus bicycle-non-motor vehicle collisions was possible. Unexpectedly, although effect size estimates for fatally injured cyclists favored bicycle-motor vehicle collisions, further analysis revealed that fatally injured cyclists were no more likely to be involved in a collision with a motor vehicle than non-fatally injured cyclists, including those who had incurred a head injury as result of their accident. Responsibility, or assignment of fault for bicycle-motor vehicle collisions, specifically, bicyclists error or motorist error was not assessable, due to lack of available studies providing relevant information.

Bicycle Safety Campaign/Intervention Hypothesis

The impact of the various interventions aimed at increasing helmet usage, among a representative sample of the population, including all socioeconomic levels and minority groups, was not able to be thoroughly evaluated. Too few studies included lower income families in their selected samples. A few entries reported observed helmet usage patterns by race. As previously noted, the results of the meta-analytic procedure revealed that whites were more likely than non-whites to be observed wearing a helmet while cycling

Significant Confounding Variables Hypothesis

None of the confounders believed to increase a cyclist's risk of incurring a bicycle-related injury (i.e., location of accident, time of day of accident, season of accident, and region of the country) were sufficiently reported by an adequate number of researchers, to permit a meta-analytic analysis by helmet usage or type of injury sustained.

Conclusion

Based on the findings of the various analytical procedures succinctly summarized above, this author concludes that researchers publishing in this area need to improve both their methodology, and their reporting of relevant information. Too few researchers evaluating the effectiveness of a campaign at increasing helmet usage among a targeted sample population, selected samples that were representative of the population at large. Aside from the issue of generalizability of findings, the importance of sample selection in this body of literature relates to the ability of parents to purchase a bicycle helmet for their children. Thus, the implementation of future research in this area that targets both those excluded, namely minorities and lower income communities, and includes samples that are more representative of the mean demographics of the United States, may prove effective in improving results evaluating particular hypotheses that are regarded as apparent to those involved in injury prevention research.

Notwithstanding the above, the findings of this meta-analysis indicate that although noted trends and directional patterns were observed, based on this review of the literature, there is not significant evidence supporting the legislation mandating compulsory bicycle helmet usage. In fact, none of the strategies currently in place to increase bicycle helmet usage, were found to have a significant positive effect on helmet usage, including legislation. Moreover, no strategy, including legislation, was found to be significantly better than any other, at increasing bicycle-helmet usage. Thus, based on results noted here, there does appear to be sufficient evidence to warrant compulsory bicycle helmet legislation.

Finally, the perceived methodological flaws in the original studies included in this meta-analysis, were discussed in relation to the potential influence that they may have had on the study findings. It is the hope of this author that their recognition will be viewed as constructive criticism, which this author also welcomes in reference to the decisions made throughout the conductance of this meta-analysis - a first experience for this author.

CHAPTER 5

DISCUSSION

The conductance of this meta-analysis was both challenging and informative. It was full of unexpected difficulties not previously encountered in the design and implementation of clinical trials. The most disturbing problem was the perceived methodological, or reporting flaws, of many of the studies. Such limitations seriously curtailed the number of composite effect size estimates, and thus testable hypotheses.

Most studies included in this review were quasi-experimental, observational or survey studies. Expectedly, quasi-experimental studies prevailed among the non-observational studies, which essentially included data acquired from medical records, medical examiners reports, health maintenance organizations, surveillance systems and police reports. Although the majority of studies were retrospective (79%), the remaining minority of studies included prospective studies (16%), one case-control study with a survey administered to a subset of subjects (2%), and a combination retrospective/prospective cohort study (2%). Conversely, the composition of the observational/survey studies were more equally distributed - observational (37%), survey (32%), interview (10%), and some combination (21%).

A variety of measures were undertaken by researchers attempting to identify the risk patterns of bicyclists, and the effectiveness of bicycle helmets in the prevention of injuries, particularly head injuries. The composition and acquisition of selected sample populations varied, as did the corresponding internal validity of the studies. The majority of non-observational researchers accessed an intact convenience sample, namely a sub-sample of cyclists receiving treatment for a bicycle-related injury. Several of these researchers also surveyed a sub-sample of the intact group for more detailed accident information. Few researchers established pseudo-cohorts; i.e., helmeted bicyclists (cases), and nonhelmeted bicyclists (controls), often retrospectively. In comparison, most observational/survey studies did just that -- observe and/or survey a group of cyclists.

Expectedly many of the above designs were plagued with various validity issues. Internal validity issues common to many studies included, inadequate sampling of minorities and lower income families, and evaluation of legislation only campaigns adjacent to communities implementing a comprehensive educational campaign, with any success of the legislation only strategy attributed solely to the effectiveness of the legislative mandate. The presence of one, or both of these issues, together with a disregard for important confounders and disparate operational definitions for head and brain injuries, predisposed studies to construct validity issues as well. Lastly, the failure of some researchers to report sufficient statistical information, or only narratively describe select results, not to mention studies involving small sample sizes, all influenced statistical conclusion validity.

The decision to be less restrictive in the selectivity criteria for study inclusion was made to increase the generalizability of the study findings, and to attempt to balance some of the methodologically poor studies, with quality studies -- an approach advocated by Glass (Glass 1981). Bryant and Wortman (1984) cautioned however, that rather than canceling each other out, what may happen is that, "Research synthesis may not be able to detect bias that operates predominately in one direction, and if it does detect bias, it may not be able to correct it (p. 12)." This may explain the overwhelming heterogeneity found in this meta-analysis, even among seemingly homogeneous samples. Furthermore, it may provide a rationale for the inability of this meta-analysis to confirm beliefs widely held by medical and injury prevention professionals, regarding the effectiveness of both bicycle helmets and compulsory bicycle helmet legislation in the prevention of bicycle-related injuries, particularly head injuries.

Nevertheless, the inclusion of documented confounding variables, or stratification variables -- variables known to have either a prognostic or incidental effect on the outcome of interest, may have attenuated some of the previously mentioned problems. Examples of potential stratification variables include socioeconomic status (SES), education, race, and age; all of which have been noted to contribute positively to helmet usage. Yet, the conductance of studies in primarily white, middle and upper middle class communities prevailed, and the inconsistencies in selected age groupings prevented more, and better, comparisons from being made. The outcome of the methodological lack of uniformity, in both study design and reporting, was an insufficient number of studies with data adequate for a more thorough investigation of potential moderators, or the conductance of separate analyses for studies deemed to be methodologically superior, in comparison to those believed to be of poorer quality. Accordingly, these problems prevented this author from providing objective evidence to rate the validity of studies included in this review. Moreover, the inclusion of predominately quasi-experimental designs likely complicated all of these issues further, and ultimately the effect size estimates. In lieu of the fact that the results of these studies undoubtedly influenced the decision to mandate helmet usage in various communities and regions of the country, such weaknesses raise serious questions as to whether legislative decisions effecting all members of a community or region, were justified.

Potential Causes of Lack of Homogeneity

The lack of homogeneity discovered among all composite effect size estimates, as indicated by rejection of the Q statistic, may have resulted from an interplay of poor methodological design and failure to apply statistical techniques that control for important variables. A number of the effect size estimates yielded large negative estimates, raising questions about the accuracy of the estimates. In his meta-analytic report on juvenile delinquency treatment, Lipsey (1992) noted that, "the possibility that methodologically low-quality studies would spuriously yield larger effect sizes than higher-quality studies, thus biasing the distribution upward and overstating the magnitude of the actual effects of treatment" was a concern (p. 99). Evaluation of the effect estimates in this review raised similar concerns. Methodological design flaws that may have contributed to the heterogeneity problems found among bicycle-related injury and helmet usage studies include patient selection characteristics, lack of stratification according to known confounder variables, and biases inherent in sequential studies from the same region. Statistical issues to be considered in relation to the threat of homogeneity include failure to apply statistical techniques that may have reduced uncontrolled variation, accounted for any differences attributable to another variable, or may have increased the power of the analyses.

Methodological Recommendations

Plausible explanations for the subject by treatment interaction indicated by the presence of heterogeneity that are related to methodological design issues focus on the incorporation or identification of confounder/moderator variables. Stratification of subjects by variables known to influence the outcome measure, such as age, gender, race, SES, education, and the severity of bicycle-related accidents may have minimized, or helped to explain, the lack of homogeneity discovered in this body of literature, and ultimately increased the power of the analyses.

Socioeconomic status (SES) and race of the subjects was infrequently reported by authors, despite the known association between these factors and trauma (Rivara & Barber 1985; Pless, Verreault & Tenina 1989; Sosin, Sacks & Smith, 1989; CDC -- Division of Injury Control, 1990; Rivara 1990; Durkin, Davidson, Kuhn, O'Connor & Barlow 1994; Price, Makintubee, Herndon & Istre 1994), and more specifically bicycle-related accidents (Kraus 1986; King 1991; Largo and Thacher-Renschaw 1993). Of those studies that did report race, caucasians/whites overwhelmingly prevailed (47.5% observational studies, and 13% non-observational studies). Spikler (1991) cautions that "inclusion of all or almost all patients in a trial from one specific ethnic background or race may lead to a trial performed in only one social or economic group. This may influence data obtained and yield a biased interpretation relating to the race or ethnic background of patients" (p. 621). Indeed, there is evidence of this bias in the bicycle-related injury and helmet data.

This study confirmed Spikler's (1991) assertion, as the exclusion of minorities from most studies in this review presented some analysis problems. Although the subject population would appear to be fairly homogeneous, favoring caucasians and the middle and upper-middle class, heterogeneity between studies persisted. Whether lower income families were directly or indirectly excluded from study enrollment is inconsequential during the analysis phase of this study, but the consequences of that decision will be continually seen. The omission of this segment of the population ignored the direct association between income and the ability to purchase an approved bicycle helmet, and the indirect association between income, race and the ability to purchase a bicycle helmet. Helmet usage among members of middle and upper middle class families predominated in observational studies (16%), while non-observational study authors generally failed to include this variable in their reports. Because these factors are so closely linked with one another, excluding them from studies that would ultimately form the basis of legislative measures that included them, appears negligent.

While the composition of the subject population of non-observational studies may not be as readily controlled as that of observational studies, the selection of network provider hospitals and geographical regions that service lower income and indigent patients, may provide information on the sample population missing from the studies reviewed by this author. Stratification methods could also be employed to reduce the apparent bias in this body of literature. Age, gender, race, socioeconomic status (SES), highest education attained by primary household member, and the severity of the bicycle-related accidents and subsequent injuries are all potential, theory-indicated, stratification factors. However, the results of this analysis, albeit premature and inconclusive, suggest that severity level would probably have had little effect on homogeneity. This judgment is based on the finding that studies whose subject population was restricted to head injured bicyclists, still did not conform with the homogeneity assumption when analyzed separately from all other non-observational studies (Refer to Table 4). This author is inclined to believe that lack of stratification on confounding factors that play a significant role in the level of risk and outcomes being measured, for example, the inability to distinguish bicyclists by age due to non-uniform categorization of bicyclists' ages among this group of researchers, prevented a more definitive meta-analysis from being performed.

In contrast to the above researchers, researchers implementing observational studies should select observation sites to include lower socioeconomic communities. Augmenting future research designs to include this previously excluded portion of the population, will provide the necessary data to enable more accurate inferences to be made to the population at large, when evaluated concurrently with previously published studies. Such studies may also permit future meta-analysts using this pool of data, to unravel the factors contributing to the lack of homogeneity found by this author. In addition, investigators may be able to formulate more informed hypotheses with theory-driven independent, dependent, and possibly moderator variables, in the examination of study relationships.

Statistical Recommendations

Application of statistical techniques, such as analysis of covariance and repeated measures, may also have minimized the effect of uncontrolled confounders, permitting the deduction of more accurate conclusions. Both of these procedures are common statistical techniques utilized when a quasi-experimental design has been selected. Analysis of covariance (ANCOVA) procedures may have been particularly helpful for non-observational study researchers who were unable to randomly assign or stratify subjects. ANCOVA procedures would have permitted these researchers to statistically adjust for a variable(s) affecting the dependent variable and causing pre-group analysis differences. These variables are called "covariates" or "nuisance variables." Post-hoc control of the variables through the application of ANCOVA, permits the results to be interpreted as though the variable(s) was constant across study groups. This is possible because the procedure assumes that the relationship (homogeneity of regression slopes) is the same for all groups. Ideally, selected covariates are highly correlated with the dependent variable, but have low correlations with one another. In the bicycle-related injury and helmet data, the examination of the intercorrelations between SES, highest educational level attained by parents/guardians, race, age and cycling experience may have provided insight into the dependency of these variables. Should dependencies have been found, ANCOVA could have been performed to control for potential differences in helmet usage among injured and non-injured cyclists, with SES and race serving as covariates (or alternate variables according to the resulting means and intercorrelations).

Covariates used in ANCOVA procedures should be measured pre-intervention to minimize the risk of removing any treatment effect. Although the use of analysis of covariance is not the most optimal procedure, nor does it overcome design flaws, it may have provided a more objective finding regarding the effectiveness of bicycle helmets in the reduction of bicycle-related injuries, with an emphasis on head injuries. Furthermore, ANCOVA may have reduced the apparent heterogeneity found throughout the effect size calculations. For a more thorough introduction to ANCOVA, consult a statistical text, or seek the advice of a statistician during the design stage of a study.

Conversely, application and complete reporting of results from repeated measures procedures, may have been most useful for researchers utilizing observational/survey techniques with more than one measurement period. Repeated measures procedures permit the researcher to control for nuisance variables that are attributed to a single subject, while reducing the number of subjects required to conduct a study with power and precision. However, one restriction of this design is the reduction in the generalizability of findings that typically can be made. Care must be taken to limit any resulting inferences to samples similar to that of the subjects studied. This constraint appeared relevant among bicycle injury and helmet usage researchers, as homogeneity was found only among those researchers reporting results from an intervention implemented in Howard County, Maryland (Cote' et al. 1992; Dannenberg et al. 1993). The lack of homogeneity of these studies when evaluated with all other studies, raises questions regarding the generalizability of the findings. Once again, acquiring statistical consultation during the design of a research study, may maximize the information that can be extricated from the data, while minimizing biases, confounders, errors, and significant violations of important statistical assumptions.

Randomization

Randomization is a property of statistical inference that most all statisticians staunchly agree should be part of a research design, unless absolutely prohibited, or a decision that can be zealously defended. The importance of randomization among studies included in a meta-analysis is expressed by several prominent meta-analysts (Glass 1981; Wachter et al. 1990; Becker 1992; Cook et al. 1992; Devine 1992; Lipsey 1992). Rubin (1990) states, "It's not that randomization cuts out detail, but that it provides an internal estimate of error" (p. 175). Cook and associates (1992) further commented, "Randomization allows us to make causal inferences from treatments to outcomes, and any meta-analysis on the effectiveness of a treatment should therefore lean heavily on randomized studies whenever possible" (p. 301). This notion was supported early on by Glass (1981) in his work on school class-size and achievement. Glass (1981) noted:

> "One methodological characteristic of the studies, however, was strongly related to the conclusions. Over 100 comparisons of achievement in smaller and larger classes came from studies in which preexisting differences between classes were controlled by random assignment to the two classes; the remaining comparisons came from studies in which poor controls were exercised (i.e., naturally occurring smaller and larger classes were compared). The studies were thus distinguished with respect to a characteristic of research method" (p. 80).

Despite the fact that meta-analysts, like statisticians, view randomized studies to be optimal, not all meta-analysts limit their selection of studies to randomized studies (Glass 1980; Devine 1992; Lipsey 1992; Becker 1992; Haher et al. 1995; Jorgensen, Johnson, Kolodziej & Schreer 1996). The population of interest for this meta-analysis, bicycle-related injury and helmet efficacy studies, may not be entirely conducive to a randomized study design. Randomization of study participants to helmet users versus non-helmet users, would likely not be deemed ethical. As such, quasi-experimental designs predominated among non-observational study designs.

The use of the quasi-experimental design, although justifiable, probably effected the results of these analyses. In his review of juvenile delinquency treatment, Mark Lipsey (1992) noted, "Since many of these studies did not use randomly assigned controlled groups, the positive mean effect size may indicate only initial non-equivalence between treatment and comparison group reappearing as a pseudo-treatment effect in the outcome measure" (p. 96). The reverse may be true among the non-observational studies included in these analyses. The bicyclists injured severely enough to warrant hospital treatment or admission, were likely different from the selected comparison group, and/or from the population of recreational cyclists at large. A myriad of possible factors could have contributed to the differences between bicyclists requiring hospital treatment and those not, and between nonhelmeted and helmeted cyclists. As previously mentioned, some of these potential factors include: inexperienced riders, separately or combined with riding on the street, risk takers performing maneuvers that would be considered to be horse-play or otherwise very risky behavior, and other similar behavioral characteristics of the individuals. In contrast, helmet users may be classified by some as more compliant, less deviant individuals who would be less likely to engage in behavior that would result in a bicycle accident.

Although the large number of effect size estimates among non-observational studies may be an indication of bias among the studies reviewed, the assessment of individual effect size estimates by study type; i.e., random assignment versus non-random assignment was not possible as too few studies randomly assigned subjects to groups. Therefore, even though a positive effect appears to be present in favor of helmet usage, the failure of these studies to meet the assumption of homogeneity, precludes their combination. Moreover, the unlikelihood that hospital personnel regularly and reliably documented the outcomes of interest (helmet usage or purchase in relation to type of injury sustained, when appropriate), together with the already suspected biased sample populations, could at least partially be imputable to the lack of homogeneity experienced.

Effect Size Distribution

Inferential problems more specific to meta-analysis that invariably effected the results, involve the issue of statistical dependence of multiple measures extracted from a single study, and/or multiple publications of findings from a given intervention. As indicated above, this problem plagued observation/survey studies more so than non-observational studies among the bicycle-related injury and helmet usage studies included in this meta-analytic review. Of the 8 entries included in the bicycle helmet usage by race analysis, three entries were from one study which separated data out by counties utilizing different interventions. Each intervention was entered separately. Thus, all three of these entries, plus one additional, represented data from the same area (4/8, 50%). Unfortunately, inclusion of all 8 entries (6 unique studies) resulted in a significant test of homogeneity. It was not until all 4 distinctly different entries were eliminated from analysis, that the homogeneity assumption was met. Therefore, this author will not attempt to draw any inferences of bicycle helmet usage by race, due to the undesirable statistical dependencies from multiple results referencing a single intervention and region of the country; i.e., Howard County, Maryland. It was believed that any attempt would result in a misrepresentation of the outcome measure of interest, bicycle helmet usage, across all studies.

The unsatisfactory property of statistical dependency was not able to be overcome through the use of alternate analyses to determine which measures were most typically assessed by the researchers included in this review, due to the lack of uniformity of reporting among this body of researchers. Lack of consistency among investigators in the reporting of findings also precluded improving statistical power by inclusion of additional studies. The pooling of information from less than 10 studies on the hypotheses of interest with associated effect sizes that, together, failed the homogeneity test, not only would have been fraught with low power, but would also have violated a major assumption of meta-analysis. Moreover, the failure of this body of literature to comply with the homogeneity assumption, prohibited the assessment of the magnitude of the intervention (helmet use/nonuse on the selected area of interest, for example assignment of fault, type of injury, etc.) from being assessed. Hence, this author refrained from purporting the provision of any definitive answers to the research questions of interest.

Study Quality

The performance of medical procedures and techniques, or the administration of drugs to patients different from those who have been studied, would lead to a multitude of clinical and malpractice issues. The conductance of injury prevention, or epidemiologic-type studies, in a more discerning manner -- similar to that of a clinical trial investigator, may minimize the design flaws, premature success reports, and incomplete reporting of data observed by this author. It may also assist the meta-analyst seeking to create effect size weighting schemes (quality and/or sample size) that yield less biased effect estimates. Hence, in the absence of sound research, the mere fact that bicycle helmets appear to make common sense, should not lead to the inference that they are the solution to the problem. Should that be the case, cigarette smoking and all its associated problems and sequela would no longer be an issue.

However, in order to improve the quality of published information, collaboration must be obtained between researchers and journal editors. Editors need to provide the journal space necessary for essential components of study reporting. Namely, publication of the methodological and statistical characteristics including the purpose, method of acquisition and composition of the patient population, and type and associated significance of statistics used, would enable reviewers to evaluate the quality and substantive nature of the published manuscript. Naturally, expanding the length of individual manuscripts would limit space availability. However, it may simultaneously compel editors to more fully evaluate the quality of manuscripts, thereby improving upon those reviewed by the intended audience.

The significance of quality research designs cannot, and should not, be underscored by findings that simply appeal to one's intuition or common sense, or are published from prominent centers or by endowed researchers. Rather, care must be taken to not ascribe cause and effect relationships in the absence of complete data, or merely on the basis of high correlations -- both of which could be influenced by unknown or untested confounders, mediating or moderating the effect. In this respect, Spikler (1991) reminds us that, "Many medicines and other modalities have been credited with causing a beneficial effect when the true reason for the patient's benefit was related to the natural history of disease and regression of disease on the severity to the mean . . . . Most problems improve to some degrees over time, regardless of the intervention (p. 550).

Limitations

Major recognized limitations of this meta-analysis include:

1.) Lack of multiple independent raters to abstract and code data from studies included in this meta-analysis.

2.) Statistical dependencies invariably complicated some analyses. However, because some studies yielded more than one measure of interest, but not all studies uniformly reported results, no single solution was recognized as best. Moreover, the number of studies that did report information on confounders, and other potentially correlated factors, were too few to aggregate findings for study.

3.) The role of judgement in a meta-analysis is evident. Inexperience on the part of this author in the conductance of a meta-analysis, probably contributed to many over-sights and potentially poor decisions that are currently unknown to this author. For this, I welcome the criticisms of more experienced meta-analysts, so that any future meta-analytic projects will be enhanced.

4.) Time limitations prohibited contacting investigators for more detailed study related information. However, although this may have provided additional information to improve upon the feasibility of this meta-analysis, it very well may have required the implementation of secondary analyses -- a procedure that was not the aim of this manuscript.

Exemplary Studies

Although a "best" study is not easily defined or identifiable, and any choice will undoubtedly be subject to debate, this author selected the following studies as they best outlined and discussed their purported issues: Ernster and Gross (1982), Selbst et al. (1987), Rodgers (1994, 1995) and Rouzier and Alto (1995). The first two are non-observational studies, and the latter two are observational/survey studies. All studies sufficiently reported all relevant information associated with the intended hypotheses for a thorough review and inclusion in a meta-analytic study.

This author found Ernster and Gross's (1982) study design and presentation best reported the information needed in an integrative study, among the non-observational studies reviewed. Ernster and Gross (1982) reported on pediatric bicycle accident victims seen in the emergency room, and followed-up with a telephone survey to acquire more detailed information associated with the accident. The study objectives were clearly stated, and definitions were provided for variables where multiple interpretations could be applied. A number of potential confounding variables were measured, and their effect on the results were discussed. The only notable problem this author had with Ernster and Gross's (1982) manuscript, was their lack of reporting of the test statistic values and confidence intervals associated with the significance tests reported.

Selbst and associates (1987) conducted the second non-observational study selected. This study appeared methodologically sound, and did not require "guesstimates" of data in tables or figures. Relevant and potentially confounding variables were assessed, and discussed, in relation to the noted injuries. Although the associated test statistics and p-values for assessed variables found to be non-significant were not reported, Selbst and colleagues did narratively address them -- a practice that was not done by the majority of authors. However, the one perceived shortcoming of Selbst and colleagues (1987) noted by this author, related to their conclusion that "the infrequent use of protective equipment and minimal safety instructions received by the patients in this study suggest that many bicycle related injuries are preventable" (p. 140). This conclusion does not seem justified in lieu of their reported finding that, "factors that were found to be not significantly associated with serious injury, multiple injury, or hospital admission included these: . . . the lack of bicycle safety instruction . . . and lack of protective equipment" (p. 141-142). Thus, the appropriateness of their conclusion is questionable, despite Selbst and associates' (1987) comment that the lack of significance was due to small sample size, as this would have systematically effected all related outcomes assessed by Selbst and associates (1987).

Rodgers (1994, 1995) clearly outlined the purpose and endpoints, methodology, sample population, and analyses, associated with his survey study. In addition, tables were presented that accurately reflected and complimented the narrative discussion, and descriptive analyses. The only criticism that I noted with Rodgers' (1994, 1995) manuscripts were that definitions or intervals were not provided to indicate what "always or almost always," "more than half of the time," "less than half of the time," and never or almost never" represented. It was difficult to distinguish where quartile values such as 75% and 25% would lie. Would these values be placed in the "more than half of the time," and "less than half of the time," categories or more precisely, in the "always or almost always," and never or almost never" categories, respectively. However, because this would represent a systematic interpretation bias for all those who completed the survey, it was felt that the error would be randomly distributed among all respondents.

Similarly, Rouzier and Alto (1995) discerningly explained the methodology and results as they pertained to the hypotheses of interest. A summary table complimented the narrative presentation of results, while providing associated test statistics and significance levels. The discussion and conclusion were succinct, nicely organized, and did not make unreasonable extrapolations to extraneous or tangential matters that were outside the scope of the stated hypotheses.

Additional non-observational studies worthy of review included Frank et al. 1995, Stutts et al. 1991, and Thompson et al. 1989. Each adequately presented the design and results components of their study, with minor limitations or extrapolations, making them worthy of notation. Other laudable observational studies include Rivara et al. 1994, Schneider et al. 1993, and Wasserman et al. 1988. These researchers adequately described their intended aims, methodology and results, thereby enabling the information necessary for data synthesis to be retrieved with little extrication.

Research Guidelines

As a result of the difficulties encountered by this novice meta-analyst, this author presents some basic guidelines that may aid future researchers, either conducting studies or meta-analyses in this area of research, to deduce more definitive and sound inferences. Conceptually, the integrative research synthesis process is analogous to the primary scientific research process. Each requires the investigator to systematically progress from a conceptualized idea to the evaluation of results. What differs is the type of data from which conclusions are inferred, and generally, the number and manner in which operational definitions are defined.

Table 25 presents a comparative review of primary and integrative research guidelines. Its purpose is to familiarize the novice researcher with the similarities and differences between the implementation of primary research, and data synthesizing research studies. Each stage of research, and its essential components, are outlined. Distinguishing characteristics between the two types of research (primary research and meta-analysis) are noted. It is the hope of this author, that the material contained in the table will illustrate the direct relationship between the two types of studies -- quality meta-analyses require quality primary research studies. The reviewer seeking a more detailed description of meta-analysis or the research process, is encouraged to consult the appropriate reference.

As a complement to Table 25, Table 26 offers rudimentary suggestions for the researcher toying with the idea of creating a database from existing or future patient chart records. Although databases can, and do, simplify some phases of the research process (i.e., computation of number and type of patients seen, patient demographics, diagnoses, treatment regimens, potential confounders, outcome, etc.), they by no means replace the process. Poor database construction, like poor study design, can severely curtail the usefulness and generalizability of any study findings.

Databases that are created in software programs or languages (SAS, SPSS, BMDP, EXCEL, Quattro Pro, etc.) that can be easily converted or transformed for statistical analyses are generally best. Collaboration with a statistician in the design phase of the database may help to minimize any number of data problems that may be encountered during the data collection and analysis phase of the research study. Information on the proper arrangement and coding of variables, may reduce the number of manipulations that are required later. Recommendations on the manner in which data reliability checks are conducted and at what intervals, may also minimize future errors and biases.

The use of databases to gather epidemiologic information (incidence and prevalence information) and possibly generate more informed hypotheses, is invaluable.

Databases afford numerous advantages when constructed and maintained properly. Such advantages include: 1.) quick access to a well-defined group of subjects, 2.) a reduction in the costs associated with manual retrieval of fundamental information by researchers seeking to study the same sample population, 3.) the potential to be less biased, particularly if the data was not collected with a specific hypothesis in mind, 4.) the entry of large numbers of patients, especially if maintained over several years and by multiple institutions, provides valuable data for the examination of treatment effects (e.g., standard versus novel) and adverse reactions, and 5.) permits a myriad of comparisons between hospitals and physicians (morbidity and mortality, and quality of life).

However, like all other scientific methods, databases also have their problems. When used inappropriately, the information contained in databases can be unreliable, and not confirmable. The use of databases to unravel the perplexicities of the complex patient, or to identify medication interactions, may result in more quandaries than answers. As such, the employment of a qualified database administrator and experienced investigator to ensure the proper maintenance and use of a large database, should be underscored.

The creation of a large injury surveillance database, or regional databases that could be linked for analysis purposes, epidemiologic and otherwise, may help to standardize the collection and reporting of data, thereby making data synthesizing both more practical and more reliable. Databases such as NEISS, NHTSA, and various regional hospital and police monitoring systems do offer a wide range of uses. However, even these databases and researchers publishing data from its reserves, lack the uniformity necessary for quality integrative studies. It appears that rather than reporting data according to uniform categories, researcher's report information that best reflect their hypothesis of interest. While this may illustrate the author's postulate, it may not lend crecidence to the theory as a whole, due to its lack of generalizability to the entire subject population of interest. With resources for research diminishing, it is time for leaders within each field to step up and demand more from themselves and from their colleagues. Minimizing scavenger hunting hypotheses testing, and designing quality studies whose findings will, whether significant or not, provide valuable information to the scientific community, is essential.

Table 25: Comparative Review of Primary and Integrative Research Guidelines

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage I: Identification of Problem	1.) Discuss purpose and aims of research. 2.) State hypotheses. 3.) Address issues of proponents and adversaries of stated problem. 4.) Provide operational definitions, as necessary.	1.) Discussion of previously published relevant research findings, and rationale for current study (animal, laboratory, human, etc.)	1.) Definition of research domain. 2.) Discussion of theoretical and/or social significance of the research.	Meta-analysis: 1.) Meta-analysts need to keep in mind that answers to the questions they pose, depend upon current literature and its quality.

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage II: Methodologic Issues	1.) Description of sample: characteristics, recruitment, consent, and withdrawal. 2.) Properties of instruments included in protocol: author/developer of instrument, validity, reliability, range and interpretation of scores 3.) Data collection personnel, forms, and monitoring. 4.) Anticipated time frame.	1.) Type of study & site selection. 2.) Primary & secondary endpoints. Early termination criteria. 3.) Identification of important variables (independent, dependent and confounding) 4.) Subject selection & representativeness, assignment, compliance, early withdrawal, and loss to follow-up procedures. 5.) Acquisition of consent 6.) Treatment-related issues: blinding, adverse reactions, extraneous biases (e.g., Hawthorne Effect), etc. 7.) Identify study personnel and associated qualifications of personnel.	1.) Type of studies to be included in review. (published only, unpublished, abstracts, studies with incomplete data, etc). 2.) Acquisition of studies (reference reviews, electronic literary databases - Medline, ERIC, etc.). 3.) Explain study eligibility - what criteria will be used to pool data (e.g., outcome or treatment). 4.) Describe abstraction and coding of studies. 5.) Specify whether and how reliability was assessed. 6.) Detail manner in which dependency information will be handled; i.e., duplicate studies, multiple outcome measures from a given study, multiple studies from the same population, multiple studies from same group of investigators, multiple measures on same subjects.	Primary Studies: More Control 1.) Researcher can precisely outline inclusion and exclusion criteria, and treatment regimen. Meta-analysis: Threats to Validity 1.) Different investigators may apply different criteria regulating valid and invalid studies (i.e., study acquisition and units within studies). 2.) Criteria or weighting schemes for study quality can vary from researcher to researcher. 3.) Operational definitions may vary from study to study, and potentially confound results (treatments may not be exactly the same)

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage II: Methodologic Issues			7.) Provide definition of quality or strategy for determining study quality. 8.) State years of study publication to be included. 9.) Consideration must be given to design differences among included studies, and the potential role they may play in introducing heterogeneity (e.g., subject characteristics, type of intervention, methodological issues - type of randomization, accuracy of variable measurements, weighted analyses, and sample size, etc.).	4.) Each researcher can choose a different method of handling non-independent data (e.g., treat as independent, average, select "best" one, perform separate analyses for each method). 5.) In comparison to primary studies, reliability error may be more ambiguous in meta-analytic studies, as it could be concealed in unknown (unreported) inconsistencies, as well as abstraction errors. 6.) No direct control over study design - must rely on primary studies.

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage III: Data Collection and Analyses	1.) Procedures for processing and analyzing data - qualitative and quantitative. 2.) Statistical programs used in analysis. Meta-analysis: 1.) Organize studies to reveal an obscured pattern.	1.) Subject-related information: anticipated number of subjects and power analysis. 2.) Provide listing of eligible patients who declined participation and attrition rates. 3.) Describe research tools (instruments to be used in study, range of possible scores, sensitivity, specificity, & reliability of tool).	1.) Explain how effect sizes are calculated. 2.) Provide rationale for the inclusion and exclusion of studies from hypotheses testing. 3.) State whether blinding of abstractor to journal type and hypotheses was done to help minimize bias.	Both: 1.) Abstractors in meta-analyses and data collectors and entry personnel in primary research, both need to be monitored with interrater reliability checks.

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage III: Data Collection and Analyses		4.) Data collection forms (monitoring techniques, verification procedures, and handling of discrepant information). 5.) Statistical issues: types of analyses, use of transformations, procedures for handling missing, drop-out, or lost to follow-up subject data, use and choice of multiple comparison procedures, and determination of interim analysis significance levels.	4.) Describe variance estimates and homogeneity analyses. 5.) Explain how effect sizes were chosen, if necessary, if more than one effect could have been calculated (e.g., based on subgroups or total groups). 6.) Identify whether , and the manner in which, statistics will be reconstituted if complete information is not provided. 7.) Decision to use sensitivity analyses to lend further credibility to results.	2.) Similar to lost to follow-up subjects in primary research, meta-analytic studies have unpublished studies, or the infamous "file-drawer" problem. 3.) Both primary research and meta-analysis rely on the integrity of investigators to accurately report findings for analysis. However, primary researchers may find it easier to check for errors than meta-analysts. Meta-analysis: 1.) Need to guard against abstractor bias favoring one treatment over another, in the direction of the hypotheses of interest. 2.) Deficiencies and errors in reporting data can seriously curtail analyses and subsequent results.

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage III: Data Collection and Analyses				3.) Need to protect against bias in the location of studies. 4.) Potential for error in the extrapolation of data from figures or tables when narrative description is not provided, and data is incompletely reported.
Stage IV: Results and Interpretation	1.) Provision of both descriptive and actual/tabled inferential statistics related to hypotheses. 2.) Description of recognized limitations and biases, and steps taken to minimize their effect (subject, investigator, statistician, etc.). 3.) Possible alternative explanations for research findings.	1.) Substantive versus statistical significance. 2.) Risk/benefit ratio. 3.) Accurate labeling of tables and figures. 4.) Inclusion of standard errors/deviations and confidence intervals. 5.) Report of non-significant results.	1.) Methodological variables have the potential to have a greater effect on study results than other study factors. 2.) Description of all judgement decisions made in the analyses; e.g., subdivision of studies to identify source(s) of heterogeneity. 3.) Explanation of factors that have potential to effect the outcome measure(s), or variables influencing the outcome measure(s); e.g., mediating variables.	Both: 1.) Require discussion of statistical versus practical significance. 2.) Rule out alternate explanations for research findings. 3.) Discussion of recognized errors of measurement and biases possibly effecting results. 4.) Examination of data for outliers, and discussion of manner in which outliers were handled. 5.) Accurate and discernable presentation of data.

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage IV: Results and Interpretation				Meta-analysis: 1.) Results from studies (data) are standardized to a common metric prior to analyses. 2.) Results can vary depending upon selection of studies, weighting criteria used for studies, reviewers interpretation of data, and operational definitions. 3.) Biases of primary research studies may be compounded when included in a meta-analytic study. 4.) Inferences rules must be clearly stated.
Stage V: Conclusions & Recommenda-tions	1.) Discussion of empirical and pragmatic adequacy of findings in relation to conceptual theory. 2.) Discussion of clinical, educational, and political implications of research findings.	1.) Generally pertains to the efficacy of a treatment or intervention. Often are more focused with respect to dosage regimens or intervention.	1.) Typically aims to examine questions that are beyond the scope of a single clinical trial or research study; i.e., may have a broader scope, but still require uniformity. 2.) Identification of gaps of knowledge or practice patterns for future studies.	Both: 1.) Researcher needs to address problems or shortcomings of study. 2.) Review of original hypotheses, and final conclusions.

Research Stage	Characteristics of Stage	Issues Specific to Primary Research Studies	Issues Specific to Integrative Research Studies	Major Differences Between Both Study Types
Stage V: Conclusions & Recommenda-tions	3.) Recommendations for future research studies.			3.) Results need to justify conclusions and purported recommendations. Meta-analysis: 1.) Ability to evaluate treatment or intervention with greater precision and power than smaller primary studies.

Table 26: Fundamental Characteristics of a Database

Section Label	Characteristics	Issues
Patient Demographics	PRIMARY CHARACTERISTICS: 1.) Identification number or code 2.) Date of birth and/or age at time of event. 3.) Gender 4.) Race SECONDARY CHARACTERISTICS: (database specific, or topic specific) 1.) Socioeconomic Status of patient, or patient's parents or legal guardian, if patient is a minor. 2.) Highest education attained by patient, or primary household provider, if patient is a minor. 3.) Occupation	1.) Need to ensure patient confidentiality. 2.) Allocate space for entry of additional event occurrences, if relevant.
Injury or Event Data	PRIMARY CHARACTERISTICS: 1.) Type, severity, and location of injuries (AIS, TRISS, etc., can be used as appropriate). ICD-9 codes may be useful if database is to be used for multiple purposes. 2.) Operative procedures (type, procedure name, and date). 3.) Status at discharge (Glasgow Outcome Score, Karnosky Index, or some tool relevant to outcome of interest). 4.) Quality of life measure, if appropriate. 5.) Previous hospitalizations for same cause of injury (e.g., bike accidents). SECONDARY CHARACTERISTICS: (database specific, or topic specific; e.g., bicycle-related accidents) 1.) Cause of accident. 2.) Type of accident. 3.) Time of day, and season of accident. 4.) ETOH and/or drug involvement. 5.) Mental capacity of injured cyclists prior to accident. 6.) Presence of other disease(s) that may have impaired the subject from safety riding a bicycle.	1.) Hospital and MD office charts can be used to gather diagnostic information. 2.) Laboratory and other information related to specific diagnostic tests, should be appropriately coded and entered.

Section Label	Characteristics	Issues
Medicinal Information (as appropriate)	PRIMARY CHARACTERISTICS: 1.) Generic name of prescribed medicine. 2.) Dosage, and frequency of administration. 3.) Side effects.	
Survey/Interview Data (as appropriate)	PRIMARY CHARACTERISTICS: 1.) Identification of person surveyed/interviewed (patient, spouse, parent, relative, care-taker, etc.) 2.) Length of time after incident/event/procedure/discharge that survey/interview was completed. 3.) Name and position of interviewer. 4.) Attrition rate 5.) Evaluation of differences between respondents and non-respondents (discernable patterns). 6.) Use of interpreters familiar with medical terminology to assist as needed, without imposing additional biases.	1.) Hawthorne effect, recall bias, unawareness of actual events. 2.) Whether to have permit open ended responses to be categorized later, or have interviewer categorize responses at time of interviewer. 3.) Interviewer must be careful not to ask questions in a "leading manner." 4.) If scales are to be used, determine format of scale and subsequent analysis. 5.) Pilot test questions for reading difficulty, double barreled items (more than one question or idea in a question), ambiguous adjectives, pronouns, misuse of negatively and positively worded items, etc.
Reliability and Validity Checks	PRIMARY CHARACTERISTICS: 1.) Monitoring procedures should be established so that periodic data checks can be done to ensure accuracy and reliability of database information. 2.) Inter-rater agreement among interviewers for classification of coded responses.	1.) Cannot rely on accuracy of hospital medical records and charting for correct coding of procedures and diagnoses. Periodic confirmation of such information should be done by database personnel.

Section Label	Characteristics	Issues
Commission of Database Information	PRIMARY CHARACTERISTICS: 1.) Written documentation of operational definitions used for coding. 2.) Statements for outside investigators seeking access to data in relation to confidentiality and other legal issues.	1.) Use of database information without knowledge of operational definitions can result in spurious results.

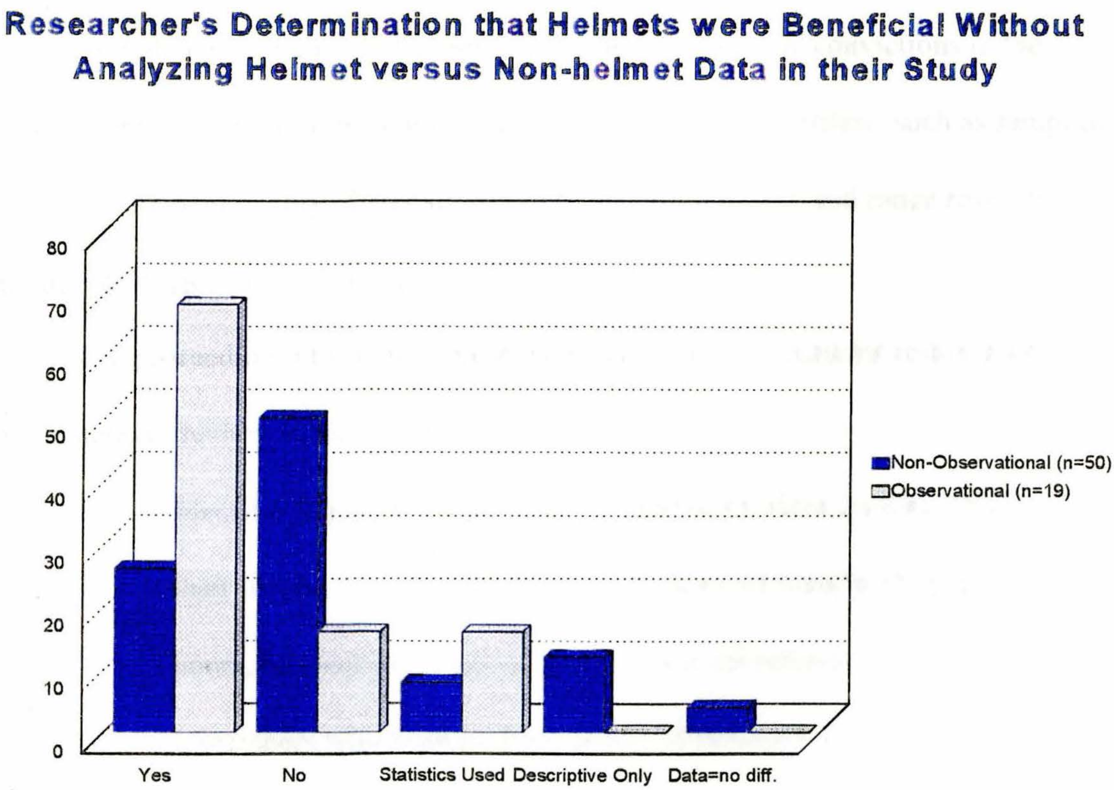
CHAPTER 6

CONCLUSION

Bicycle safety and injury prevention have become the center of attention in recent years. Characteristically, the interest in bicycle safety in the lay community is precipitated by the severe or fatal injury of a child from a bicycle-related accident. Parents and family members establish coalitions to "prevent this from happening to someone else's child" -- a tactic that either helps them to overcome, or repress, their ensuing grief. In contrast, certain groups of health care professionals are asked to salvage as much life as possible, even when the quality of life that remains is often controversial. The boisterous requests by these individuals to comply with various injury prevention strategies likely are influenced by a variety of reasons, which are intensified when sustained by children: 1.) the desire to minimize the years of potential life lost, 2.) to reduce the number of perceived unavailing fatalities incurred each year, and 3.) to help contain the mounting health care costs associated with the long-term hospitalization and rehabilitation of traumatically injured children.

Thus, although the union of lay people and health care professionals in the coalition to mandate compulsory helmet legislation is often ignited by different events, both have the same endpoint, namely, the reduction of the number of untimely deaths among children. However, in the emotional and frustrating yearning to find a solution, health care professionals need to ensure that they do not abandon the scientific research process, in favor of a hasty solution that appeals to one's intuition. Rather, as professionals, we must ensure that the perceived solution has been accurately and reliably investigated, with appropriate sample populations, methodology, statistics, and proper interpretation. Concluding that a safety intervention has a significant effect on the unsafe behavior targeted, in the absence of any statistical evidence to support the affirmation, has an increased likelihood in resulting in erroneous practices (See Figure 14).

Figure 14:



This author attempted to perform a thorough review of the literature associated with bicycle-related injuries and helmet usage patterns among cyclists, through the application of meta-analytic techniques. Unfortunately, evaluation of many of the common perceptions regarding bicycle-related accidents, was prohibited by the inadequate reporting of relevant data. Therefore, meta-analytic techniques were applied to data only where sufficient information on the hypotheses of interest was found. In order to demonstrate the impact that meta-analysis can have on a body of literature previously subject to traditional review methods only, prevailing findings from this author's review of the literature will be presented first, followed by the results of application of quantitative analytic techniques used in meta-analysis. This will provide the reader with a quantitative indication of whether predominate convictions in the bicycle literature may have been the result of various forms of artifact, such as sampling error, measurement quality, disregard of important confounders, and range restriction.

Traditional Review of the Literature

The proceeding information presents the characteristic patterns found from a comprehensive review of the literature:

1.) Most bicycle-related injuries are sustained by male cyclists, children less than 16 years of age, take place in the summer months, during daylight hours, on clear days, and occur in residential settings. However, some researchers who examined the gender differences more closely, found that the male propensity for bicycle-related injuries could be attributed to the greater amount of miles cycled by males in comparison to females. Furthermore, although males were noted to incur more injuries than females, females were found to sustain more severe injuries than their male counterparts.

2.) Children are more likely to incur a bicycle accident while riding with other children, in comparison to riding with adults.

3.) Among the few researchers reporting bicycle-related accidents by socioeconomic status, a preponderance of injuries were sustained by those residing in lower income and poverty areas.

4.) Most bicycle-related accidents do not involve collisions with a motor-vehicle. Although when such collisions do occur, an inverse relationship between age (< 16 years and ≥ 16 years) and responsibility for the accident exists.

5.) Conflicting reports were found between hospital based studies and non-hospital based studies regarding the incidence and prevalence of certain types of injuries among cyclists. Moreover, the type of facility (trauma center versus general hospital, and children's hospital versus general hospital) also impacted the reported injury profile of cyclists. Generally speaking however, orthopedic injuries appear to be the prevailing type of injury among cyclists with minor or moderate injuries, with extremity injuries predominating. In contrast, neurologic injuries appear to be associated with more severe, and fatal injuries.

6.) Motorists were found to be implicated more in adult bicycle accidents, while children were implicated more than motorists in their accidents. This pattern reveals an inverse relationship between age and responsibility for the accident, that at times, reverses with the elderly. This suggests a positive correlation between the age of the rider, experience of the rider, and the ability to respond to conditions that precipitate a bicycle accident. Expectedly, the same pattern documented in children, is also found among the elderly. Both of these sub-populations lack the cognitive ability and dexterity to react quickly and correctly when riding on the road.

7.) Most children are not aware of the "the rules of the road," when riding on roadways, and how to properly maintain a bicycle to prevent bicycle malfunctions from causing an accident.

8.) A proclivity exists for the effectiveness of bicycle helmets in the prevention of major injuries. However, little evidence appear to exists regarding their efficaciousness in reducing the incidence of minor injuries. This belief appears common among avid and professional cyclists as well, who despite the United States Cycling Federation Ruling requiring professional cyclists to don a bicycle helmet during all training and official events, voluntarily admit that they do not regularly wear a bicycle helmet during training.

9.) Reasons commonly reported for non-helmet usage are varied, but common responses include: comfort, riding short distances, didn't see the need, dislikes helmets, forgot, and peers do not wear helmets.

Meta-Analysis Results

Insufficient and inconsistent reporting of relevant data, or factors, precluded this author's ability to thoroughly investigate the bicycle-related injury and helmet literature, and associated hypotheses of interest, as initially intended. This author sought to compare the findings from a traditional narrative review of the literature, with that of a meta-analysis, a quantitative review of the literature. However, only four meta-analytic procedures were possible: 1.) injury and helmet usage, 2.) injury and type of accident (motor vehicle related or non-motor vehicle related, 3.) race and helmet usage, and 4.) current strategies and helmet usage. The first two hypotheses were tested using the information extracted from non-observational studies, while the second two were evaluated using the information extricated from observational/survey studies. This happened unintentionally, due to the nature of what was reported in the respective sub-divisions of the bicycle injury and helmet literature.

Heterogeneity, or the inability of a composite effect size estimate to adequately describe the outcomes of studies being integrated, rendered the results of all analyses questionable. In addition, the lack of uniformity in reporting important potential confounders, or variables with a moderating or mediating effect on the outcomes of interest, prohibited formal model testing procedures from being conducted to identify variables that accounted for the noted variability in the effect size estimates. Notwithstanding the above limitation, the following results were found:

1.) Most injured cyclists were not wearing a helmet at the time of the accident.

2.) Although head injured subjects appeared less likely than injured cyclists as a whole, to be wearing a helmet at the time of their accident, the difference in helmet usage was found to be insignificant.

3.) Fatally injured cyclists were no more likely to be involved in a collision with a motor vehicle than non-fatally injured cyclists, including those who had incurred a head injury as a result of their accident.

4.) Whites were more likely than non-whites to wear a bicycle helmet.

5.) None of the strategies currently in place to increase bicycle helmet usage, were found to have a significant positive effect, including legislation.

Comparative Findings

Overlooking the lack of homogeneity found in all meta-analytic procedures permits the identification of suggestive patterns, albeit variant, that underlie the associations and causations forming the basis of this area of research. In so doing, the integration of this body of literature supported the prevailing belief that most injured cyclists were not wearing a bicycle helmet at the time of their accident. However, in contrast to the belief maintained by the populace of bicycle helmet advocates, that head injured cyclists are significantly more likely than non-head injured subjects to not be wearing a helmet at the time of their accident, no significant difference was found between subjects from predominately or exclusively head injured studies, and those studies reporting on all bicycle-related injuries in general. A finding even more intriguing to this author was that, fatally injured cyclists were just as likely to be involved in a collision with a motor vehicle than non-fatally injured cyclists, including those who had sustained a head injury as a result of their collision.

Unlike the information promulgated by the media, researchers reporting on the effectiveness and need for bicycle helmets, investigators receiving private, state, and federal funds in the area of bicycle injury prevention and helmet efficacy, and other helmet advocates, this author had no incentive to find an answer that supported one opinion or another. Rather, a concerted effort was made to evaluate the literature objectively, free of any provocation. As such, this manuscript took the "devil's advocate" approach at times, that appeared missing from the bicycle injury and helmet literature. In so doing, this author discovered many issues that went overlooked or unaddressed. At the fore-front of these, was the exclusion of minorities and lower income families and neighborhoods by the majority of researchers. Therefore, it was not surprising that the integration of study outcomes revealed racial disparities in favor of whites, in the evaluation helmet usage. Similarly, it was also not surprising that although differences existed in the magnitude of the interventions currently endorsed by bicycle helmet advocates (legislation, education, and joint education and community approaches), all were found to be equally ineffective in increasing helmet usage among bicyclists. Thus, the serious methodological errors and biases noted throughout this review, that went undetected in the review of individual manuscripts in this field of research, may have had unperceived influence on the outcomes of studies used in this integrative analysis.

Plausible Influential Factors

In the examination of relationships among variables, evidence that does not appear to favor the efficaciousness of bicycle helmets in the prevention of bicycle-related injuries is suggested by the concurrent consideration of published research reports with information provided by the U.S. Consumer Reports, and the National Highway Traffic Safety Association (NHTSA). Consumer Reports documented a rise in the ubiquitous use of bicycles in the Unites States, while review of NHTSA documentation reveals that the number of fatal traffic accidents involving bicyclists have remained essentially unchanged since 1980. Moreover, the reported incidence of bicycle-related head injuries has also remained fairly constant over the years.

The rationale underlying those advocates of bicycle helmets that purport that bicycle helmet legislation is a necessity due to the large number of children severely injured or killed each year as a result of bicycle-related traffic accidents, would have to make mandatory protective gear for pedestrians a priority over bicycle helmets. The percentage fatality rate for pedalcyclists versus pedestrians for those who were killed or injured in traffic accidents was less for pedalcyclists than for pedestrians (2% versus

3%, respectively) -- a statistic that had remained unchanged from 1993 (later reports were unavailable to this author at the time of writing) (U.S. Department of Transportation 1995, p. 85). This statistic appeared to remain constant (pedestrians greater than pedalcyclists) for all age groups (U.S. Department of Transportation 1994-1995).

This information raises questions as to the exigency and rationale for legislation mandating bicycle helmets. No-one is promoting pedestrians wear a padded suit of armor to cross the street, and yet pedestrians incur more injuries and fatalities in traffic related accidents than do bicyclists (U.S. Department of Transportation 1994-1995). However, most affluent professionals and policy makers would shun the idea of wearing protective clothing to and from work, during lunch hours, etc., or every time they needed to cross a street to get to a destination. Yes, this may sound foolish, but what is too much? Are adults requiring children to comply with measures that are also un-necessary, in lieu of their ability to draft a better solution. Are policies being made that impact others aside from those encouraging and passing them? Are legislators pacifying affluent vociferous members of our society; i.e., physicians, family and friends of children from higher status neighborhoods where a child was killed or severely debilitated as a result of a bicycle accident, by passing legislation? Does the possibility that more affluent children have likely replace bicycling as a childhood pastime with nintendo and other computerized games, influence the opposition from more affluent families? Does economics and the political process obscure the seemingly hasty passage of bicycle helmet legislation? This author quibbles with such questions, in light of the events that generated the passage of much of the bicycle helmet legislation in the United States.

The passage of compulsory helmet legislation, will do little to enhance the knowledge and judgement of children riding on roadways. It will also have little impact on reducing the amount of horseplay and stunts performed by some. In fact, it may very well increase such behavior, due to a misplaced sense of "added protection" from injury. Furthermore, and most lamentable, compulsory helmet legislation will deny impoverished children from the pleasurable pastime of riding a bicycle -- an activity that despite the gun fire, gang behavior, drug activity, and depressed living conditions, enables them to behave as children, without definitive evidence supporting its efficaciousness.

It is easy for those who can afford bicycle helmets to encourage and legislate the compulsory use of them. The solution appears both sensible and simple. However, the integration of all studies that investigated bicycle related injuries, and not just those whose primary aim was to show the benefit of bicycle helmets, revealed the complexity of the problem of bicycle injuries, and the insufficient evidence to warrant mandatory usage by any member of our society. Thus, it appears that no one measure currently in place to increase bicycle helmet usage is significantly better than any other, including legislation. Therefore, in the haste to identify a solution to the problem, many people and things suffered, particularly children unable to ride their bicycles because of their parents inability to purchase a helmet, and the quality of research. Thus, based on this review of the literature and application of meta-analytic procedures, although bicycle helmets may afford protection to some, compulsory helmet legislation appears to be a superfluous solution to a much more complex problem.

Until researchers can demonstrate that the protection offered by bicycle helmets in the reduction of injury and death incurred by cyclists, is significantly better than non-helmet usage, this author is not convinced that it is equitable to mandate that all bicyclists wear a bicycle helmet, or forfeit their right to ride a bicycle without having a fine levied upon them. Should better quality research provide the evidence currently lacking to support the enactment of legislation for all cyclists, it is the hope of this author that subsidies commensurate with the income level of families, will be made available for those unable to afford to purchase helmets. Free helmet coupons for parents of children living in poverty conditions, better subsidies for middle to lower income families, or possibly the instillation of provisions by Health Maintenance Organizations for members to receive discounted or free helmets, may all help the numerous Americans who simply are overwhelmed by many other financial difficulties. After all, one should not forget that the aim of injury prevention is not to unjustifiably eliminate a traditional pastime enjoyed by people of all socioeconomic levels since the mid 1800's -- riding a bicycle, it is to improve the safety and quality of life of those participating in a given activity, thereby reducing the associated morbidity and mortality. Bicycling is more than a sport that results in injuries. It is a recreational pastime, a method of transportation, a form of exercise, and a common means of socialization for children of all backgrounds. Establishing mandates that abolish bicycling for all those individuals, who themselves, or whose parents simply could not afford a bicycle helmet, in the absence of significant evidence necessitating its implementation, is wrong. In lieu of the findings reported here, hopefully, some of my colleagues will reconsider their continued endorsement of such unjust policies, until the time comes when better quality research either supports their position, or provides a better alternative.

APPENDIX A

REFERENCES FOR STUDIES INCLUDED IN ANALYSES

References for Studies Included in Analyses

Non-Observational Studies

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*Part 1 of part 1/part 2 study.

APPENDIX B

STUDY CODING SHEET

APPENDIX B

Study Coding Sheet

Study Inclusion Period:

General Study Information		
Study ID:	**Year:**	**Authors:**
Primary Author's Education: _____MD _____Ph.D. _____MS _____RN _____Other, specify:		
Journal Type: _____Medical _____Educational _____Safety _____Allied Health _____Public Health _____Scientific _____Other, specify:		
Professional Affiliation of 1° Author: _____1° Injury Prevention Center _____Hospital Only _____Trauma Center _____Academic/Teaching Institution _____Governmental Agency _____Other, specify:		
Study Characteristics		
Location of Study: _____NE _____SE _____MW _____SW _____W _____Nation-wide		
Type of Study: _____Retrospective _____Prospective _____Cohort _____Case-Control _____Survey/Observational		

Type of Data: _____Hospital Data
_____Inpatient Only
_____Outpatient Only
_____Both

Type of Hospital: _____Community Hospital
_____Medical Center

Location of Hospital: _____Urban
_____Rural

Classification of Hospital: _____1° Care Hospital _____Tertiary Care Hospital

_____Mortality/Fatality Data

_____Observational/Survey Data

_____Surveillance System Data
_____NEISS _____CDC _____National Registry Data
_____NHTSA _____Other, specify:

Subject Characteristics

Total # of Subjects:

Gender: Male:____ Female: ____

%Male:____ %Female:____

Race: _____White _____%M
_____Black _____%M
_____Hispanic _____%M
_____Asian _____%M
_____Native American _____%M
_____Unknown _____%M

Summary: _____White _____%M
_____Non-white _____%M

Special Subject Categories

_____**Students:**
_____Elementary School _____%M
_____Middle School _____%M
_____High School _____%M
_____College _____%M

_____**Adults Only** _____%M

_____**Both** _____%M

Cycling Patterns
Cyclists _____**Professional/Competitive Cyclists (# / %)** _____**Recreational Cyclists (# / %)** _____Road Cyclists: __________ _____%M _____Road Cyclists: __________ _____%M _____Off-Road Cyclists: __________ _____%M _____Off-Road Cyclists: __________ _____%M

	MALES						FEMALES								
	<15		≥15		ALL MALES		<15		≥15		ALL FEMALES		ALL SUBJECTS		ALL
	W	NW	W	NW	W	NW	W	NW	NW	W	NW	W	W	NW	
Education															
High School or Less															
Some College															
College Graduate															
Graduate School+															
Unknown															

SES															
Upper-Upper-Middle															
Middle															
Low															
Unknown															
Accident Type															
Falls															
Contact w/ Stationary Object															
Contact w/ Other Moving Object															
Contact w/ Motor Vehicle															

Cause of Accident															
Environmental															
Poor Road Conditions															
Bicyclist Error															
Motorist Error															
Bicycle Malfunction															
Unknown															
Season of Accident															
Spring															
Summer															
Fall															
Winter															

Time of Accident															
7AM-2:59PM															
3PM-8:59PM															
9PM-6:59AM															
Location of Accident															
Major Roadway															
Neighborhood															
Bike Path															

Injuries *Severe (Hospitalization)*															
Head															
Outcome Good Moderate/ Severe Fatal															
Orthopedic															
Outcome Good Moderate/ Severe Fatal															
Other															
Outcome Good Moderate/ Severe Fatal															
Helmet (#/%) *Use* *Owned*															

Injuries *Moderate (Physician Exam/ER Visit)*															
Head															
Outcome Good Moderate/ Severe Fatal															
Orthopedic															
Outcome Good Moderate/ Severe Fatal															
Other															
Outcome Good Moderate/ Severe Fatal															
Helmet (#/%) *Use* *Owned*															

Injuries *Minor (Self Treatment)*															
Head															
Outcome Good Moderate/ Severe Fatal															
Orthopedic															
Outcome Good Moderate/ Severe Fatal															
Other															
Outcome Good Moderate/ Severe Fatal															
Helmet (#/%) *Use* *Owned*															

Injuries *No Reported Injuries*															
Head															
Outcome Good Moderate/ Severe Fatal															
Orthopedic															
Outcome Good Moderate/ Severe Fatal															
Other															
Outcome Good Moderate/ Severe Fatal															
Helmet (#/%) *Use* *Owned*															

Helmet Usage/Compliance Issues															
Program Type															
Legislative															
Community															
School-Based															
Combination															
Influential Factor/Person															
Legislative															
Friends/Peers															
Parents/Family															
MD's															
Teachers															

Part B

Helmet Usage Data

Sample Characteristics									
Group Name/ Characteristics		**#/% Observations**				**# Helmeted**			
		Baseline	**F/U - 1**	**F/U - 2**	**Total**	**Baseline**	**F/U - 1**	**F/U - 2**	**Total**
Group 1:									
Total									
Gender	M:								
	F:								
Race	W								
	B								
	Other:								
Site	School								
	Road								
	Residential								
	Park/Path								

Sample Characteristics									
Group Name/ Characteristics		**#/% Observations**				**# Helmeted**			
		Baseline	**F/U - 1**	**F/U - 2**	**Total**	**Baseline**	**F/U - 1**	**F/U - 2**	**Total**
Group 1:									
SES	Upper/ Upper-Middle								
	Middle								
	Low								
	Unknown								
Helmets Sold (#/%)									
Group 2:									
Total									
Gender	M:								
	F:								
Race	W								
	B								
	Other:								

Sample Characteristics									
Group Name/ Characteristics		**#/% Observations**				**# Helmeted**			
		Baseline	**F/U - 1**	**F/U - 2**	**Total**	**Baseline**	**F/U - 1**	**F/U - 2**	**Total**
Site	School								
	Road								
	Residential								
	Park/Path								
SES	Upper/ Upper-Middle								
	Middle								
	Low								
	Unkown								
Helmets Sold (#/%)									
Group 3:									
Total									
Gender	M:								
	F:								

Sample Characteristics									
Group Name/ Characteristics		**#/% Observations**				**# Helmeted**			
		Baseline	**F/U - 1**	**F/U - 2**	**Total**	**Baseline**	**F/U - 1**	**F/U - 2**	**Total**
Race	W								
	B								
	Other:								
Site	School								
	Road								
	Residential								
	Park/Path								
SES	Upper/ Upper-Middle								
	Middle								
	Low								
	Unkown								
Helmets Sold (#/%)									

Helmet Survey Results						
Question/Topic	**Gender**			**Children/Adults**		
	Males	**Females**	**Total**	**Children (< 15)**	**Adults (≥ 15)**	**Total**
Children using helmet by race: W: (#/%) B: (#/%) Other: (#/%)						
Helmet Law is Good: Y(Agree) N(Disagree)						
Do you wear a bike helmet? Always Sometimes Never Unknown						

Reason for not wearing a helmet: Appearance Uncomfortable Peer Pressure Decrease Cycle Performance Not necessary Didn't think about it Forgot						
Do you own a bicycle helmet? Y: (#/%) N: (#/%) Unk: (#/%)						
Reason for not purchasing a helmet: Cost Comfort Appearance Didn't think about it						

Riding w/ Companions? Y: #(%)/Helmet Use by Subject (#/%) N: #(%)/Helmet Use by Subject (#/%)						
Companions wearing a helmet? Y: (#/%) N: (#/%) Unk: (#/%)						
Notes:						

APPENDIX C

QUALITY OF STUDY FORM

Quality of Study Form

(Components used to identify best study by quality, when duplicate data was found, and points assigned to each)

Component	Points
Study Design	
Description of type of study (retrospective, prospective, cohort, case-control, and survey/observational)	2
Description of type of data (hospital, mortality only, observational/survey/questionnaire, surveillance system data)	2
Description of campaign/program being implemented or reviewed	2
Report of study time period/frame (i.e., when data was collected)	2
Location of study	2
TOTAL	10
Subject Population	
Description of subject selection procedures	3
Description of subjects excluded and reason for exclusion	3
Summary reports of outcome measures of interest (injury profile and helmet use)	
➧According to the gender of the subjects	3
➧According to the age of the subjects	3
➧According to the race of the subjects	3
➧According to the socioeconomic status of the subjects (including highest education attained and financial status of the primary household members)	3
➧According to either anatomic injury location or type of injury sustained by the subjects	3
If indicated, control/comparison group was comparable to the study/intervention group	2
If indicated, study outcomes measures were assessed for each group in the study	2
TOTAL	25
Study Statistics and Results	
Subjects included in the various analyses were clearly specified	4
Sample sizes remained consistent for analyses on a specified population of subjects	4
Sample sizes were consistent for pre/post intervention studies	4
Reported frequencies or proportions equaled the stated sample size	5
Subgroup analyses/results were reported such that differences could be discerned from the total sample size	4
Descriptive interpretations of graphical data was provided for more precise reporting of data values	4

Test statistics and probability values were provided when definitive conclusions were stated (i.e., effectiveness, or ineffectiveness)	5
TOTAL	30
<u>Report of Confounding Variables of Interest</u>	
Location of bicycle accident reported	2
Cause of bicycling accident reported	2
Type of collision reported	2
Report of season in which bicycle accident occurred	2
Time of day of accident	2
TOTAL	10
<u>Issues Specific to Observational Studies</u>	
Observational locations and times were defined	2
Observational locations and times remained constant if baseline/follow-up data was being evaluated	2
Observational locations and times were comparable if two or more populations were being evaluated	3
Observers were adequately trained, i.e., for determination of subject age, etc.	3
TOTAL	10
<u>Issues Specific to Survey/Questionnaire Studies</u>	
Response rate provided	2
Sample size of subjects in pre/post test designs remained constant	4
TOTAL	6
<u>Overlapping Study Inclusion Periods</u>	
Study includes all subjects in other study(ies)	5
Able to separate out data for studies that do not overlap completely	4
TOTAL	9

APPENDIX D

BICYCLE-RELATED INJURY DATA BY TYPE OF ACCIDENT: MVA OR NON-MVA ACCIDENT

Table D-1: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies - Fatality Only Studies Excluded)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	-0.7456	-0.82 / -0.67	-.3495	.0000	+4.702	%-14882.461
2-Ashbaugh	-0.2289	-0.61 / +0.16	-.1154	.2412	+5.203	-699.211
3-Selbst	-1.7618	-1.90 / -1.62	-.6615	.0000	+3.673	%-2524.805
4-Friede	-2.2800	-2.43 / -2.13	-.7522	.0000	+3.154	%-1726.148
5-Ernester	-1.5808	-1.93 / -1.24	-.6235	.0000	+3.851	-480.219
6-Halek	+5.6173	+5.15 / +6.08	+.9425	.0000	+11.050	%-2148.195
7-Yelon	+0.0945	-0.21 / +0.40	+.0476	.5387	+5.527	%-1281.297
8-Largo	-1.4592	-1.77 / -1.15	-.5922	.0000	+3.973	-641.906
9-Watts	-0.0394	-0.21 / +0.13	-.0198	.6571	+5.395	%-3679.313
10-Tucci	-2.8196	-3.14 / -2.50	-.8170	.0000	+2.612	-261.773
11-McKenna	-6.8495	-7.36 / -6.34	-.9602	.0000	-1.418	-29.445
12-King	-0.8970	-1.18 / -0.61	-.4118	.0000	+4.535	-952.984
13-Frank	-0.6700	-0.83 / -0.51	-.3183	.0000	+4.765	%-3340.445
14-Hawley	This case was marked and excluded in this analysis					
15-Boswell	This case was marked and excluded in this analysis					
16-Rodgers-1b	This case was marked and excluded in this analysis					
17-Belongia	-2.2134	-2.47 / -1.96	-.7433	.0000	+3.219	-600.656
18-Kraus	-0.7177	-0.90 / -0.54	-.3386	.0000	+4.716	%-2621.328
19-Jaffe	+0.2315	-0.25 / +0.71	+.1176	.3357	+5.663	-541.570
20-Li-1	-0.0746	-0.13 / -0.02	-.0373	.0108	+5.388	%-33643.957
21-Thompson-2a	-1.8509	-1.98 / -1.72	-.6796	.0000	+3.585	%-3001.289
22-Thompson-2b	-9.4746	-9.88 / -9.06	-.9785	.0000	-4.044	-373.266
23-Stutts-1a	-1.7310	-1.86 / -1.60	-.6549	.0000	+3.705	%-3236.375
24-Flora	-5.5104	-5.51 / -5.51	-.9400	.0000	-4.647	%-72595.000
Overall:	-5.4313	-5.44 / -5.43	-.9384	.0000	4.516	%-7107.698

Note: Q(20)= 77638.578; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-1091827 TWDS = 6007716 TW = 201023.6
Largest outlier is Flora

Qw(23) = 77638.578; p = 0.0000;
sums are: TWD =-1091827 ; TWDS = 6007716 ; TW = 201023.6 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 08-12-1997 at 19:17:56, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file MVANOMVA.DAT.

Table D-2: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies - Head Emphasis Injury Studies Excluded)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	-0.7456	-0.82 / -0.67	-.3495	.0000	+4.725	%-15034.230
2-Ashbaugh	-0.2289	-0.61 / +0.16	-.1154	.2412	+5.227	-705.621
3-Selbst	-1.7618	-1.90 / -1.62	-.6615	.0000	+3.697	%-2557.664
4-Friede	-2.2800	-2.43 / -2.13	-.7522	.0000	+3.178	%-1752.313
5-Ernester	-1.5808	-1.93 / -1.24	-.6235	.0000	+3.875	-486.168
6-Halek	+5.6173	+5.15 / +6.08	+.9425	.0000	+11.073	%-2157.461
7-Yelon	+0.0945	-0.21 / +0.40	+.0476	.5387	+5.551	%-1292.352
8-Largo	-1.4592	-1.77 / -1.15	-.5922	.0000	+3.997	-649.617
9-Watts	-0.0394	-0.21 / +0.13	-.0198	.6571	+5.419	%-3711.859
10-Tucci	-2.8196	-3.14 / -2.50	-.8170	.0000	+2.636	-266.566
11-McKenna	-6.8495	-7.36 / -6.34	-.9602	.0000	-1.395	-28.469
12-King	-0.8970	-1.18 / -0.61	-.4118	.0000	+4.559	-963.012
13-Frank	-0.6700	-0.83 / -0.51	-.3183	.0000	+4.789	%-3373.922
14-Hawley	+1.0866	+0.58 / +1.59	+.4857	.0000	+6.542	-652.633
15-Boswell	+1.2000	-0.15 / +2.55	+.6000	.0515	+6.655	-93.836
16-Rodgers-1b	+2.1317	+2.02 / +2.25	+.7296	.0000	+7.598	%-16855.609
17-Belongia	This case was marked and excluded in this analysis					
18-Kraus	This case was marked and excluded in this analysis					
19-Jaffe	This case was marked and excluded in this analysis					
20-Li-1	This case was marked and excluded in this analysis					
21-Thompson-2a	-1.8509	-1.98 / -1.72	-.6796	.0000	+3.608	%-3041.328
22-Thompson-2b	-9.4746	-9.88 / -9.06	-.9785	.0000	-4.020	-368.883
23-Stutts-1a	-1.7310	-1.86 / -1.60	-.6549	.0000	+3.729	%-3278.145
24-Flora	-5.5104	-5.51 / -5.51	-.9400	.0000	-4.661	%-50900.836
Overall:	-5.4551	-5.46 / -5.45	-.9389	.0000	4.847	%-5408.526

Note: Q(19)= 57780.039; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-1090888 TWDS = 6008713 TW = 199974.9
Largest outlier is Flora

Qw(23) = 57780.039; p = 0.0000;
sums are: TWD =-1090888 ; TWDS = 6008713 ; TW = 199974.9 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 08-12-1997 at 19:22:32, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file MVANOMVA.DAT.

Table D-3: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies - Fatality and Head Emphasis Studies Excluded)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	-0.7456	-0.82 / -0.67	-.3495	.0000	+4.737	%-15108.980
2-Ashbaugh	-0.2289	-0.61 / +0.16	-.1154	.2412	+5.239	-708.781
3-Selbst	-1.7618	-1.90 / -1.62	-.6615	.0000	+3.709	%-2573.867
4-Friede	-2.2800	-2.43 / -2.13	-.7522	.0000	+3.190	%-1765.230
5-Ernester	-1.5808	-1.93 / -1.24	-.6235	.0000	+3.887	-489.102
6-Halek	+5.6173	+5.15 / +6.08	+.9425	.0000	+11.085	%-2162.016
7-Yelon	+0.0945	-0.21 / +0.40	+.0476	.5387	+5.562	%-1297.797
8-Largo	-1.4592	-1.77 / -1.15	-.5922	.0000	+4.008	-653.422
9-Watts	-0.0394	-0.21 / +0.13	-.0198	.6571	+5.431	%-3727.891
10-Tucci	-2.8196	-3.14 / -2.50	-.8170	.0000	+2.648	-268.934
11-McKenna	-6.8495	-7.36 / -6.34	-.9602	.0000	-1.383	-27.992
12-King	-0.8970	-1.18 / -0.61	-.4118	.0000	+4.571	-967.953
13-Frank	-0.6700	-0.83 / -0.51	-.3183	.0000	+4.800	%-3390.418
14-Hawley	This case was marked and excluded in this analysis					
15-Boswell	This case was marked and excluded in this analysis					
16-Rodgers-1b	This case was marked and excluded in this analysis					
17-Belongia	This case was marked and excluded in this analysis					
18-Kraus	This case was marked and excluded in this analysis					
19-Jaffe	This case was marked and excluded in this analysis					
20-Li-1	This case was marked and excluded in this analysis					
21-Thompson-2a	-1.8509	-1.98 / -1.72	-.6796	.0000	+3.620	%-3061.078
22-Thompson-2b	-9.4746	-9.88 / -9.06	-.9785	.0000	-4.008	-366.742
23-Stutts-1a	-1.7310	-1.86 / -1.60	-.6549	.0000	+3.740	%-3298.746
24-Flora	-5.5104	-5.51 / -5.51	-.9400	.0000	-4.222	%-36358.121
Overall:	-5.4668	-5.47 / -5.46	-.9391	.0000	4.461	%-4483.945

Note: Q(16)= 40175.730; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-1091531 TWDS = 6007363 TW = 199665.2
Largest outlier is Flora

Qw(23) = 40175.730; p = 0.0000;
sums are: TWD =-1091531 ; TWDS = 6007363 ; TW = 199665.2 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 08-12-1997 at 19:21:06, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file MVANOMVA.DAT.

Table D-4: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies - Fatality and Head Emphasis Studies Only)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	This case was marked and excluded in this analysis					
2-Ashbaugh	This case was marked and excluded in this analysis					
3-Selbst	This case was marked and excluded in this analysis					
4-Friede	This case was marked and excluded in this analysis					
5-Ernester	This case was marked and excluded in this analysis					
6-Halek	This case was marked and excluded in this analysis					
7-Yelon	This case was marked and excluded in this analysis					
8-Largo	This case was marked and excluded in this analysis					
9-Watts	This case was marked and excluded in this analysis					
10-Tucci	This case was marked and excluded in this analysis					
11-McKenna	This case was marked and excluded in this analysis					
12-King	This case was marked and excluded in this analysis					
13-Frank	This case was marked and excluded in this analysis					
14-Hawley	+1.0866	+0.58 / +1.59	+.4857	.0000	+0.887	-11.891
15-Boswell	+1.2000	-0.15 / +2.55	+.6000	.0515	+0.994	-2.089
16-Rodgers-1b	+2.1317	+2.02 / +2.25	+.7296	.0000	+2.333	%-1312.536
17-Belongia	-2.2134	-2.47 / -1.96	-.7433	.0000	-2.508	-352.135
18-Kraus	-0.7177	-0.90 / -0.54	-.3386	.0000	-0.996	-108.630
19-Jaffe	+0.2315	-0.25 / +0.71	+.1176	.3357	+0.024	-0.010
20-Li-1	-0.0746	-0.13 / -0.02	-.0373	.0108	-0.937	-308.274
21-Thompson-2a	This case was marked and excluded in this analysis					
22-Thompson-2b	This case was marked and excluded in this analysis					
23-Stutts-1a	This case was marked and excluded in this analysis					
24-Flora	This case was marked and excluded in this analysis					
Overall:	+0.2076	+0.16 / +0.26	+.1033	.0000	1.240	-299.366

Note: Q(6)= 1630.069; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD = 346.4036 TWDS = 1701.998 TW = 1668.25
Largest outlier is Rodgers-1b

Qw(23) = 1630.069; p = 0.0000;
sums are: TWD = 346.4036 ; TWDS = 1701.998 ; TW = 1668.25 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-20-1997 at 12:28:39, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file MVA-GRP1.DAT.

Table D-5: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies - Head Emphasis Studies Only)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	This case was marked and excluded in this analysis					
2-Ashbaugh	This case was marked and excluded in this analysis					
3-Selbst	This case was marked and excluded in this analysis					
4-Friede	This case was marked and excluded in this analysis					
5-Ernester	This case was marked and excluded in this analysis					
6-Halek	This case was marked and excluded in this analysis					
7-Yelon	This case was marked and excluded in this analysis					
8-Largo	This case was marked and excluded in this analysis					
9-Watts	This case was marked and excluded in this analysis					
10-Tucci	This case was marked and excluded in this analysis					
11-McKenna	This case was marked and excluded in this analysis					
12-King	This case was marked and excluded in this analysis					
13-Frank	This case was marked and excluded in this analysis					
14-Hawley	This case was marked and excluded in this analysis					
15-Boswell	This case was marked and excluded in this analysis					
16-Rodgers-1b	This case was marked and excluded in this analysis					
17-Belongia	-2.2134	-2.47 / -1.96	-.7433	.0000	-2.084	-241.202
18-Kraus	-0.7177	-0.90 / -0.54	-.3386	.0000	-0.547	-32.246
19-Jaffe	+0.2315	-0.25 / +0.71	+.1176	.3357	+0.455	-3.454
20-Li-1	-0.0746	-0.13 / -0.02	-.0373	.0108	+1.010	-168.690
21-Thompson-2a	This case was marked and excluded in this analysis					
22-Thompson-2b	This case was marked and excluded in this analysis					
23-Stutts-1a	This case was marked and excluded in this analysis					
24-Flora	This case was marked and excluded in this analysis					
Overall:	-0.2179	-0.27 / -0.16	-.1083	.0000	1.024	-111.398

Note: Q(3)= 287.703; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-296.0326 TWDS = 352.2134 TW = 1358.473
Largest outlier is Belongia

Qw(23) = 287.703; p = 0.0000;
sums are: TWD =-296.0326 ; TWDS = 352.2134 ; TW = 1358.473 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-20-1997 at 20:34:51, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file MVA-GRP1.DAT.

Table D-6: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies - Fatality Only Studies)

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	This case was marked and excluded in this analysis					
2-Ashbaugh	This case was marked and excluded in this analysis					
3-Selbst	This case was marked and excluded in this analysis					
4-Friede	This case was marked and excluded in this analysis					
5-Ernester	This case was marked and excluded in this analysis					
6-Halek	This case was marked and excluded in this analysis					
7-Yelon	This case was marked and excluded in this analysis					
8-Largo	This case was marked and excluded in this analysis					
9-Watts	This case was marked and excluded in this analysis					
10-Tucci	This case was marked and excluded in this analysis					
11-McKenna	This case was marked and excluded in this analysis					
12-King	This case was marked and excluded in this analysis					
13-Frank	This case was marked and excluded in this analysis					
14-Hawley	+1.0866	+0.58 / +1.59	+.4857	.0000	-1.038	-15.632
15-Boswell	+1.2000	-0.15 / +2.55	+.6000	.0515	-0.880	-1.629
16-Rodgers-1b	+2.1317	+2.02 / +2.25	+.7296	.0000	+1.031	-17.434
17-Belongia	This case was marked and excluded in this analysis					
18-Kraus	This case was marked and excluded in this analysis					
19-Jaffe	This case was marked and excluded in this analysis					
20-Li-1	This case was marked and excluded in this analysis					
21-Thompson-2a	This case was marked and excluded in this analysis					
22-Thompson-2b	This case was marked and excluded in this analysis					
23-Stutts-1a	This case was marked and excluded in this analysis					
24-Flora	This case was marked and excluded in this analysis					
Overall:	+2.0739	+1.96 / +2.19	+.7198	.0000	0.983	-11.565

Note: Q(2)= 17.458; p = 0.0002;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD = 642.4361 TWDS = 1349.785 TW = 309.7769
Largest outlier is Rodgers-1b

Qw(23) = 17.458; p = 0.0002;
sums are: TWD = 642.4361 ; TWDS = 1349.785 ; TW = 309.7769 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-20-1997 at 20:36:23,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file MVA-GRP1.DAT.

APPENDIX E

HELMET VERSUS NON-HELMET INJURY DATA FOR STUDIES WITH MEASURABLE EFFECT SIZE ESTIMATES FOR BOTH POSTULATES OF INTEREST

Table E-1: Helmet versus Non-Helmet Injury Data for Studies with Measurable Effect Size Estimates for Both Postulates of Interest (Non-Observational Studies)

Helmet Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Thompson	This case was marked and excluded in this analysis					
2-Selbst	-13.0325	-13.61 /-12.46	-.9885	.0000	-9.851	%-1118.777
3-Watts	-2.1368	-2.37 / -1.91	-.7312	.0000	+1.298	-110.664
4-Tucci	-4.6280	-5.58 / -3.67	-.9216	.0000	-1.313	-7.230
5-Frank	-4.7797	-5.09 / -4.47	-.9228	.0000	-1.533	-90.154
6-Warren	This case was marked and excluded in this analysis					
7-Belongia	-9.9770	-10.97 / -8.98	-.9808	.0000	-6.687	-172.150
8-Jaffe	-5.4429	-6.47 / -4.41	-.9412	.0000	-2.131	-16.336
9-Li-1	-7.4369	-7.60 / -7.28	-.9657	.0000	-5.012	%-3040.362
10-Thompson2a	-1.6671	-1.79 / -1.54	-.6407	.0000	+2.367	-970.563
11-Thompson2b	-1.2616	-1.39 / -1.13	-.5341	.0000	+2.871	%-1376.200
12-Gerberich	This case was marked and excluded in this analysis					
13-Spaite	This case was marked and excluded in this analysis					
14-Stutts-1a	-5.9264	-6.18 / -5.67	-.9476	.0000	-2.810	-440.641
Overall:	-3.3216	-3.39 / -3.25	-.8567	.0000	3.587	-734.308

Note: Q(9)= 6055.272; p = 0.0000;
d's are positive for differences in the Helmeted direction.
effect sizes corrected for bias.
sums are: TWD =-2736.558 TWDS = 15145.16 TW = 823.8556
Largest outlier is Li-1

Qw(13) = 6055.272; p = 0.0000;
sums are: TWD =-2736.558 ; TWDS = 15145.16 ; TW = 823.8556 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-22-1997 at 10:52:04,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file HELMET1.DAT.

End-of-Output

Table E-2: Bicycle-Related Injury Data by Type of Accident: MVA or Non-MVA Accident (Non-Observational Studies)
10 Coded Entries with Measureable Effect Sizes Estimates for Both Postulates of Interest

MVA/NonMVA - Grp 1 Data

Study	d	95% CI	r	p	Dev.	Homo.
1-Zavoski	This case was marked and excluded in this analysis					
2-Ashbaugh	This case was marked and excluded in this analysis					
3-Selbst	-1.7618	-1.90 / -1.62	-.6615	.0000	-1.038	-184.785
4-Friede	This case was marked and excluded in this analysis					
5-Ernester	This case was marked and excluded in this analysis					
6-Halek	This case was marked and excluded in this analysis					
7-Yelon	This case was marked and excluded in this analysis					
8-Largo	This case was marked and excluded in this analysis					
9-Watts	-0.0394	-0.21 / +0.13	-.0198	.6571	+0.818	-79.845
10-Tucci	-2.8196	-3.14 / -2.50	-.8170	.0000	-2.044	-157.486
11-McKenna	This case was marked and excluded in this analysis					
12-King	This case was marked and excluded in this analysis					
13-Frank	-0.6700	-0.83 / -0.51	-.3183	.0000	+0.151	-3.141
14-Hawley	This case was marked and excluded in this analysis					
15-Boswell	This case was marked and excluded in this analysis					
16-Rodgers-1b	This case was marked and excluded in this analysis					
17-Belongia	-2.2134	-2.47 / -1.96	-.7433	.0000	-1.440	-117.065
18-Kraus	This case was marked and excluded in this analysis					
19-Jaffe	+0.2315	-0.25 / +0.71	+.1176	.3357	+1.051	-18.498
20-Li-1	-0.0746	-0.13 / -0.02	-.0373	.0108	+1.541	%-1323.155
21-Thompson-2a	-1.8509	-1.98 / -1.72	-.6796	.0000	-1.161	-282.424
22-Thompson-2b	-9.4746	-9.88 / -9.06	-.9785	.0000	-8.753	%-1731.189
23-Stutts-1a	-1.7310	-1.86 / -1.60	-.6549	.0000	-1.029	-223.365
24-Flora	This case was marked and excluded in this analysis					
Overall:	-0.8111	-0.85 / -0.77	-.3758	.0000	1.902	-412.095

Note: Q(9)= 3333.128; p = 0.0000;
d's are positive for differences in the MVA-Bike direction.
effect sizes corrected for bias.
sums are: TWD =-1811.046 TWDS = 4802.129 TW = 2232.734
Largest outlier is Thompson-2b

Qw(23) = 3333.128; p = 0.0000;
sums are: TWD =-1811.046 ; TWDS = 4802.129 ; TW = 2232.734 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-21-1997 at 20:27:32, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file MVA-GRP1.DAT.

APPENDIX F

HELMET USAGE PATTERNS BY RACE

Table F-1: Helmet Usage Patterns by Race: 4 Entries with Greatest Percentage of Whites and Non-Significant Effect Size Estimates (Observational/Non-observational Studies)

race-grp2

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+0.1782	-0.23 / +0.59	+.0889	.0372	+0.028	-0.013
2-Dannenberg-Balt	+0.1999	-0.27 / +0.67	+.0996	.0178	+0.053	-0.039
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Fullerton	This case was marked and excluded in this analysis					
5-Cote-HowCo	+0.4170	-0.14 / +0.98	+.2054	.0238	+0.301	-0.957
6-Liller	+0.0371	-0.29 / +0.36	+.0186	.7423	-0.204	-0.895
7-Rivara-#110	This case was marked and excluded in this analysis					
8-DiGuiseppi-#111	This case was marked and excluded in this analysis					
Overall:	+0.1576	-0.05 / +0.37	+.0786	.0020	0.146	-0.476

Note: Q(3)= 1.395; p = 0.7067;
d's are positive for differences in the white-helmeted direction.
effect sizes corrected for bias.
sums are: TWD = 14.0301 TWDS = 3.606487 TW = 89.00534
Largest outlier is Cote-HowCo

Qw(7) = 1.395; p = 0.7067;
sums are: TWD = 14.0301 ; TWDS = 3.606487 ; TW = 89.00534 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-25-1997 at 10:32:22, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file RACE-G2.DAT.

End-of-Output

Table F-2: Helmet Usage Patterns by Race: 4 Studies with the Most Minorities and Significant Effect Size Estimates (Observational Studies)

race-grp2

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	This case was marked and excluded in this analysis					
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	+0.6270	+0.37 / +0.88	+.2994	.0000	+0.402	-9.119
4-Fullerton	+0.7823	+0.30 / +1.26	+.3669	.0003	+0.550	-5.048
5-Cote-HowCo	This case was marked and excluded in this analysis					
6-Liller	This case was marked and excluded in this analysis					
7-Rivara-#110	+0.7868	+0.60 / +0.97	+.3664	.0000	+0.582	-35.057
8-DiGuiseppi-#111	+0.1851	+0.14 / +0.23	+.0921	.0000	-0.551	-50.713
Overall:	+0.2369	+0.19 / +0.28	+.1176	.0000	0.521	-24.984

Note: Q(3)= 51.723; p = 0.0000;
d's are positive for differences in the white-helmeted direction.
effect sizes corrected for bias.
sums are: TWD = 464.554 TWDS = 161.7649 TW = 1961.162
Largest outlier is DiGuiseppi-#111

Qw(7) = 51.723; p = 0.0000;
sums are: TWD = 464.554 ; TWDS = 161.7649 ; TW = 1961.162 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-25-1997 at 10:29:23, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file RACE-G2.DAT.

End-of-Output

APPENDIX G

EXAMINATION OF STRATEGIES TO PROMOTE BICYCLE HELMET USAGE

Table G-1: Examination of Strategies to Promote Bicycle Helmet Usage: Legislation Only Entries Included (including Beachwood)

Intervention-Helmet Use Data Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.334	-341.483
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-Elementar	This case was marked and excluded in this analysis					
10-Weiss-HighSchoo	This case was marked and excluded in this analysis					
11-Weiss-College-N	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Pendergrast-Lit	This case was marked and excluded in this analysis					
14-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	-0.388	-3.701
15-Cote-BaltimoreC	This case was marked and excluded in this analysis					
16-Cote-Montgomery	This case was marked and excluded in this analysis					
17-Dannenberg2-Bal	This case was marked and excluded in this analysis					
18-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-1.262	-480.451
19-Dannenberg2-Mon	This case was marked and excluded in this analysis					
20-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+0.949	-197.980
21-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	-0.624	-46.403
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Macknin&Mendend	This case was marked and excluded in this analysis					
24-Puczynski&Marsh	This case was marked and excluded in this analysis					
25-Liller	This case was marked and excluded in this analysis					
26-Rouzier&Alto	This case was marked and excluded in this analysis					
27-Rivara	This case was marked and excluded in this analysis					
28-DiGuiseppi-Seat	This case was marked and excluded in this analysis					
29-DiGuiseppi-Port	This case was marked and excluded in this analysis					
Overall:	+0.0268	-0.03 / +0.08	+.0134	.3305	0.911	-214.004

Note: Q(4)= 740.147; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD = 32.82785 TWDS = 741.0278 TW = 1223.872
Largest outlier is Dannenberg2-HowardCo

Qw(28) = 740.147; p = 0.0000;
sums are: TWD = 32.82785 ; TWDS = 741.0278 ; TW = 1223.872 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 09-29-1997 at 22:14:59, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file INTERVTN.DAT.

End-of-Output

Table G-2: Examination of Strategies to Promote Bicycle Helmet Usage: Only Legislation Only Entries (including Beachwood) AND Joint Education and Community Entries Included

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.676	-593.656
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.033	-0.026
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	This case was marked and excluded in this analysis					
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-0.395	-62.478
18-Dannenberg2-Mon	This case was marked and excluded in this analysis					
19-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+1.318	-430.964
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	-0.153	-2.944
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+2.517	-261.807
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.737	-530.741
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.785	-36.019
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	-0.015	-0.067
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-1.207	-439.551
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	This case was marked and excluded in this analysis					
Overall:	-0.3854	-0.43 / -0.34	-.1892	.0000	1.084	-235.825

Note: Q(9) = 2115.381; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-812.5233 TWDS = 2428.501 TW = 2108.437
Largest outlier is Dannenberg-HowCo

Qw(29) = 2115.381; p = 0.0000;
sums are: TWD =-812.5233 ; TWDS = 2428.501 ; TW = 2108.437 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-05-1997 at 15:26:08,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table G-3: Examination of Strategies to Promote Bicycle Helmet Usage: All Types of Interventions with Legislation Only (including Beachwood) AND Education Only Entries Excluded

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.729	-629.954
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+0.617	-139.389
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-5.411	-514.145
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.076	-0.142
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.715	-168.140
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-0.340	-46.037
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-2.314	%-1414.231
19-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+1.372	-465.436
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	-0.108	-1.460
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	This case was marked and excluded in this analysis					
24-Liller	This case was marked and excluded in this analysis					
25-Rouzier&Alto	This case was marked and excluded in this analysis					
26-Rivara	This case was marked and excluded in this analysis					
27-DiGuiseppi-Seat	This case was marked and excluded in this analysis					
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-1.563	-22.824
30-Weiss-Elem-B to	This case was marked and excluded in this analysis					
Overall:	-0.4279	-0.47 / -0.38	-.2092	.0000	1.624	-340.176

Note: Q(9)= 3000.073; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-882.2827 TWDS = 3377.619 TW = 2061.798
Largest outlier is Dannenberg2-MontgomeryCo

Qw(29) = 3000.073; p = 0.0000;
sums are: TWD =-882.2827 ; TWDS = 3377.619 ; TW = 2061.798 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 20:02:59, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file INTERVT1.DAT.

End-of-Output

Table G-4: Examination of Strategies to Promote Bicycle Helmet Usage: All Types of Interventions with No Direct Interventions Excluded (including Beachwood)

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.836	-738.323
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+0.755	-227.586
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-5.237	-482.966
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.235	-1.377
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.546	-148.376
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-0.113	-5.661
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-2.020	%-1134.910
19-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+1.484	-570.941
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	+0.060	-0.463
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+2.706	-304.444
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.503	-448.441
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.574	-19.382
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+0.213	-13.785
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.909	-264.510
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-1.402	-18.388
30-Weiss-Elem-B to	This case was marked and excluded in this analysis					
Overall:	-0.5864	-0.62 / -0.55	-.2813	.0000	1.506	-291.970

Note: Q(14)= 4052.075; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-1727.634 TWDS = 5065.093 TW = 2946.364
Largest outlier is Dannenberg2-MontgomeryCo

Qw(29) = 4052.075; p = 0.0000;
sums are: TWD =-1727.634 ; TWDS = 5065.093 ; TW = 2946.364 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 15:41:30,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table G-5: Examination of Strategies to Promote Bicycle Helmet Usage: All Types of Interventions Included EXCEPT for Education Only Entries

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+2.163	%-1046.377
2-Dannenberg-Balt	-0.0389	-0.16 / +0.08	-.0195	.5131	+0.960	-241.100
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	-3.1551	-3.34 / -2.97	-.8450	.0000	-2.296	-587.722
5-DiGuiseppi	+0.2431	+0.06 / +0.43	+.1211	.0104	+1.206	-156.354
6-Kimmel&Nagel	-5.9137	-6.31 / -5.52	-.9476	.0000	-5.018	-621.774
7-Fullerton&Becke	+0.1896	-0.31 / +0.69	+.0968	.4506	+1.122	-19.355
8-Ruch-Ross&O'Con	-1.4139	-1.50 / -1.32	-.5775	.0000	-0.553	-126.267
9-Weiss-HighSchoo	+8.0350	+7.03 / +9.04	+.9710	.0000	+8.972	-305.885
10-Weiss-College-N	+5.1733	+4.70 / +5.65	+.9333	.0000	+6.129	-645.442
11-Pendergrast-Lit	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	+19.6599	+18.68 /+20.64	+.9949	.0000	+20.609	%-1682.118
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.579	-8.356
14-Cote-BaltimoreC	+2.0898	+1.52 / +2.66	+.7297	.0000	+3.027	-109.336
15-Cote-Montgomery	This case was marked and excluded in this analysis					
16-Dannenberg2-Bal	-2.6096	-2.72 / -2.50	-.7939	.0000	-1.842	%-1039.207
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	+0.290	-38.978
18-Dannenberg2-Mon	This case was marked and excluded in this analysis					
19-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+1.817	-877.441
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	+0.414	-22.102
21-Macknin&Mendend	-1.6688	-1.88 / -1.46	-.6419	.0000	-0.757	-47.649
22-Macknin&Mendend	-1.3812	-1.54 / -1.22	-.5691	.0000	-0.471	-31.186
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+3.043	-386.151
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.140	-329.669
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.224	-2.963
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+0.582	-106.050
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.503	-83.474
28-DiGuiseppi-Port	-5.9948	-6.20 / -5.79	-.9487	.0000	-5.196	%-2521.492
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-1.119	-14.754
Overall:	-0.9282	-0.96 / -0.90	-.4210	.0000	2.841	-442.048

Note: Q(24)= 10665.445; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-3561.862 TWDS = 13971.4 TW = 3837.575
Largest outlier is DiGuiseppi-Portland

Qw(29) = 10665.445; p = 0.0000;
sums are: TWD =-3561.862 ; TWDS = 13971.4 ; TW = 3837.575 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 15:38:21,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table G-6: Examination of Strategies to Promote Bicycle Helmet Usage: Only Joint Education and Community Entries Included

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Intervention-Helmet Use Data
Intervention ES's for Comparisons
```

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowCThis case was marked and excluded in this analysis						
2-Dannenberg-BaltThis case was marked and excluded in this analysis						
3-Dannenberg-MontThis case was marked and excluded in this analysis						
4-Wasserman This case was marked and excluded in this analysis						
5-DiGuiseppi This case was marked and excluded in this analysis						
6-Kimmel&Nagel This case was marked and excluded in this analysis						
7-Fullerton&BeckeThis case was marked and excluded in this analysis						
8-Ruch-Ross&O'ConThis case was marked and excluded in this analysis						
9-Weiss-HighSchooThis case was marked and excluded in this analysis						
10-Weiss-College-NThis case was marked and excluded in this analysis						
11-Pendergrast-LitThis case was marked and excluded in this analysis						
12-Pendergrast-LitThis case was marked and excluded in this analysis						
13-Cote-HowardCo This case was marked and excluded in this analysis						
14-Cote-BaltimoreCThis case was marked and excluded in this analysis						
15-Cote-MontgomeryThis case was marked and excluded in this analysis						
16-Dannenberg2-BalThis case was marked and excluded in this analysis						
17-Dannenberg2-HowThis case was marked and excluded in this analysis						
18-Dannenberg2-MonThis case was marked and excluded in this analysis						
19-Macknin&MendendThis case was marked and excluded in this analysis						
20-Macknin&MendendThis case was marked and excluded in this analysis						
21-Macknin&MendendThis case was marked and excluded in this analysis						
22-Macknin&MendendThis case was marked and excluded in this analysis						
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+3.189	-408.391
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.259	-343.444
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.207	-2.396
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+0.912	-174.724
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.728	-113.545
28-DiGuiseppi-PortThis case was marked and excluded in this analysis						
29-Weiss-Elem-A This case was marked and excluded in this analysis						
30-Weiss-Elem-B toThis case was marked and excluded in this analysis						
Overall:	-0.9557	-1.02 / -0.89	-.4311	.0000	1.459	-208.500

```
Note: Q(4)=    879.599; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
      sums are: TWD =-845.3512  TWDS = 1687.474  TW = 884.5658
 Largest outlier is Puczynski&Marshall-Comm+Educ
```

```
Qw( 29 ) =    879.599; p = 0.0000;
     sums are: TWD =-845.3512 ; TWDS = 1687.474 ; TW = 884.5658 .
     Dev.= deviation of d from the mean d excluding d.
     The marginal for Dev. is the average absolute deviation.
     Homo.= amount of reduction to Qw if effect size removed.
     The marginal for Homo. is average reduction per effect size.
     This table was created using DSTAT 1.11 on 10-01-1997 at 19:59:21,
     and these data were written to OUTPUT.DST.  The raw effect sizes
     are stored in the file INTERVT1.DAT.
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End-of-Output
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Table G-7: Examination of Strategies to Promote Bicycle Helmet Usage: All Types of Interventions Included EXCEPT for Joint Education and Community Only Entries

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+2.197	%-1078.239
2-Dannenberg-Balt	-0.0389	-0.16 / +0.08	-.0195	.5131	+0.993	-257.793
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+1.149	-549.944
4-Wasserman	-3.1551	-3.34 / -2.97	-.8450	.0000	-2.266	-572.304
5-DiGuiseppi	+0.2431	+0.06 / +0.43	+.1211	.0104	+1.237	-164.476
6-Kimmel&Nagel	-5.9137	-6.31 / -5.52	-.9476	.0000	-4.988	-614.408
7-Fullerton&Becke	+0.1896	-0.31 / +0.69	+.0968	.4506	+1.152	-20.402
8-Ruch-Ross&O'Con	-1.4139	-1.50 / -1.32	-.5775	.0000	-0.520	-111.431
9-Weiss-HighSchoo	+8.0350	+7.03 / +9.04	+.9710	.0000	+9.002	-307.927
10-Weiss-College-N	+5.1733	+4.70 / +5.65	+.9333	.0000	+6.159	-651.803
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-4.857	-415.915
12-Pendergrast-Lit	+19.6599	+18.68 /+20.64	+.9949	.0000	+20.639	%-1687.016
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.609	-9.246
14-Cote-BaltimoreC	+2.0898	+1.52 / +2.66	+.7297	.0000	+3.057	-111.512
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.168	-107.747
16-Dannenberg2-Bal	-2.6096	-2.72 / -2.50	-.7939	.0000	-1.812	%-1003.854
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	+0.325	-48.963
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-1.564	-697.780
19-Macknin&Mendend	+0.7533	+0.64 / +0.87	+.3528	.0000	+1.851	-909.746
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	+0.445	-25.537
21-Macknin&Mendend	-1.6688	-1.88 / -1.46	-.6419	.0000	-0.727	-43.902
22-Macknin&Mendend	-1.3812	-1.54 / -1.22	-.5691	.0000	-0.440	-27.228
23-Puczynski&Marsh	This case was marked and excluded in this analysis					
24-Liller	This case was marked and excluded in this analysis					
25-Rouzier&Alto	This case was marked and excluded in this analysis					
26-Rivara	This case was marked and excluded in this analysis					
27-DiGuiseppi-Seat	This case was marked and excluded in this analysis					
28-DiGuiseppi-Port	-5.9948	-6.20 / -5.79	-.9487	.0000	-5.167	%-2492.683
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-1.029	-9.902
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-1.089	-13.976
Overall:	-0.9580	-0.99 / -0.93	-.4320	.0000	3.018	-477.349

Note: Q(24)= 11441.516; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-3631.621 TWDS = 14920.52 TW = 3790.936
Largest outlier is DiGuiseppi-Portland

Qw(29) = 11441.516; p = 0.0000;
sums are: TWD =-3631.621 ; TWDS = 14920.52 ; TW = 3790.936 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 15:39:02, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file INTERVT1.DAT.

End-of-Output

Table G-8: Examination of Strategies to Promote Bicycle Helmet Usage: Only Education Only Entries AND Joint Education and Community Only Entries

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	This case was marked and excluded in this analysis					
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+1.479	-754.457
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-4.818	-406.952
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	This case was marked and excluded in this analysis					
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.117	-102.011
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	This case was marked and excluded in this analysis					
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-1.671	-711.352
19-Macknin&Mendend	This case was marked and excluded in this analysis					
20-Macknin&Mendend	This case was marked and excluded in this analysis					
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+3.183	-416.760
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.092	-307.649
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.129	-0.967
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+0.781	-168.028
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.456	-59.747
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-1.027	-12.378
Overall:	-1.0238	-1.07 / -0.98	-.4557	.0000	1.775	-294.030

Note: Q(9) = 2528.443; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-1766.012 TWDS = 4336.51 TW = 1724.936
Largest outlier is Dannenberg-MontgCo

Qw(29) = 2528.443; p = 0.0000;
sums are: TWD =-1766.012 ; TWDS = 4336.51 ; TW = 1724.936 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-05-1997 at 15:23:43, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file INTERVT1.DAT.

End-of-Output

Table G-9: Examination of Strategies to Promote Bicycle Helmet Usage: Only Education Only Entries Included

Intervention-Helmet Use Data
Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowCThis case was marked and excluded in this analysis						
2-Dannenberg-BaltThis case was marked and excluded in this analysis						
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+2.642	%-1433.784
4-Wasserman This case was marked and excluded in this analysis						
5-DiGuiseppi This case was marked and excluded in this analysis						
6-Kimmel&Nagel This case was marked and excluded in this analysis						
7-Fullerton&BeckeThis case was marked and excluded in this analysis						
8-Ruch-Ross&O'ConThis case was marked and excluded in this analysis						
9-Weiss-HighSchooThis case was marked and excluded in this analysis						
10-Weiss-College-NThis case was marked and excluded in this analysis						
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-4.802	-399.769
12-Pendergrast-LitThis case was marked and excluded in this analysis						
13-Cote-HowardCo This case was marked and excluded in this analysis						
14-Cote-BaltimoreCThis case was marked and excluded in this analysis						
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.078	-96.839
16-Dannenberg2-BalThis case was marked and excluded in this analysis						
17-Dannenberg2-HowThis case was marked and excluded in this analysis						
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-2.069	-836.964
19-Macknin&MendendThis case was marked and excluded in this analysis						
20-Macknin&MendendThis case was marked and excluded in this analysis						
21-Macknin&MendendThis case was marked and excluded in this analysis						
22-Macknin&MendendThis case was marked and excluded in this analysis						
23-Puczynski&MarshThis case was marked and excluded in this analysis						
24-Liller This case was marked and excluded in this analysis						
25-Rouzier&Alto This case was marked and excluded in this analysis						
26-Rivara This case was marked and excluded in this analysis						
27-DiGuiseppi-SeatThis case was marked and excluded in this analysis						
28-DiGuiseppi-PortThis case was marked and excluded in this analysis						
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-0.902	-7.549
30-Weiss-Elem-B toThis case was marked and excluded in this analysis						
Overall:	-1.0921	-1.16 / -1.02	-.4793	.0000	2.498	-554.981

Note: Q(4)= 1637.186; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-915.1105 TWDS = 2636.591 TW = 837.9261
Largest outlier is Dannenberg-MontgCo

Qw(29) = 1637.186; p = 0.0000;
sums are: TWD =-915.1105 ; TWDS = 2636.591 ; TW = 837.9261 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 19:58:25,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table G-10: Examination of Strategies to Promote Bicycle Helmet Usage: All Types of Interventions Included EXCEPT for Legislation Only Entries (Including Beachwood)

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowCThis case was marked and excluded in this analysis						
2-Dannenberg-Balt	-0.0389	-0.16 / +0.08	-.0195	.5131	+1.381	-494.346
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+1.570	%-1012.416
4-Wasserman	-3.1551	-3.34 / -2.97	-.8450	.0000	-1.912	-406.360
5-DiGuiseppi	+0.2431	+0.06 / +0.43	+.1211	.0104	+1.601	-274.615
6-Kimmel&Nagel	-5.9137	-6.31 / -5.52	-.9476	.0000	-4.641	-531.355
7-Fullerton&Becke	+0.1896	-0.31 / +0.69	+.0968	.4506	+1.503	-34.695
8-Ruch-Ross&O'Con	-1.4139	-1.50 / -1.32	-.5775	.0000	-0.124	-6.263
9-Weiss-HighSchoo	+8.0350	+7.03 / +9.04	+.9710	.0000	+9.352	-332.295
10-Weiss-College-N	+5.1733	+4.70 / +5.65	+.9333	.0000	+6.512	-728.355
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-4.509	-358.262
12-Pendergrast-Lit	+19.6599	+18.68 /+20.64	+.9949	.0000	+20.991	%-1744.724
13-Cote-HowardCo This case was marked and excluded in this analysis						
14-Cote-BaltimoreC	+2.0898	+1.52 / +2.66	+.7297	.0000	+3.408	-138.523
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-1.818	-75.751
16-Dannenberg2-Bal	-2.6096	-2.72 / -2.50	-.7939	.0000	-1.443	-630.833
17-Dannenberg2-HowThis case was marked and excluded in this analysis						
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-1.194	-403.559
19-Macknin&MendendThis case was marked and excluded in this analysis						
20-Macknin&MendendThis case was marked and excluded in this analysis						
21-Macknin&Mendend	-1.6688	-1.88 / -1.46	-.6419	.0000	-0.371	-11.428
22-Macknin&Mendend	-1.3812	-1.54 / -1.22	-.5691	.0000	-0.078	-0.851
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+3.430	-489.976
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-1.758	-221.982
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	+0.161	-1.529
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+1.009	-315.003
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.085	-2.382
28-DiGuiseppi-Port	-5.9948	-6.20 / -5.79	-.9487	.0000	-4.822	%-2165.105
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-0.679	-4.318
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-0.739	-6.442
Overall:	-1.3066	-1.34 / -1.27	-.5469	.0000	3.004	-415.655

Note: Q(24)= 9974.590; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-4509.8 TWDS = 15866.96 TW = 3451.63
Largest outlier is DiGuiseppi-Portland

Qw(29) = 9974.590; p = 0.0000;
sums are: TWD =-4509.8 ; TWDS = 15866.96 ; TW = 3451.63 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 15:35:29,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table G-11: Examination of Strategies to Promote Bicycle Helmet Usage: All Types of Interventions Included EXCEPT for Education Only Entries and Legislation Only Entries (including Beachwood)

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	This case was marked and excluded in this analysis					
2-Dannenberg-Balt	-0.0389	-0.16 / +0.08	-.0195	.5131	+1.498	-565.582
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	-3.1551	-3.34 / -2.97	-.8450	.0000	-1.862	-380.902
5-DiGuiseppi	+0.2431	+0.06 / +0.43	+.1211	.0104	+1.690	-302.737
6-Kimmel&Nagel	-5.9137	-6.31 / -5.52	-.9476	.0000	-4.582	-516.816
7-Fullerton&Becke	+0.1896	-0.31 / +0.69	+.0968	.4506	+1.574	-38.012
8-Ruch-Ross&O'Con	-1.4139	-1.50 / -1.32	-.5775	.0000	-0.047	-0.853
9-Weiss-HighSchoo	+8.0350	+7.03 / +9.04	+.9710	.0000	+9.424	-337.323
10-Weiss-College-N	+5.1733	+4.70 / +5.65	+.9333	.0000	+6.592	-745.094
11-Pendergrast-Lit	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	+19.6599	+18.68 /+20.64	+.9949	.0000	+21.067	%-1756.833
13-Cote-HowardCo	This case was marked and excluded in this analysis					
14-Cote-BaltimoreC	+2.0898	+1.52 / +2.66	+.7297	.0000	+3.481	-144.349
15-Cote-Montgomery	This case was marked and excluded in this analysis					
16-Dannenberg2-Bal	-2.6096	-2.72 / -2.50	-.7939	.0000	-1.416	-586.249
17-Dannenberg2-How	This case was marked and excluded in this analysis					
18-Dannenberg2-Mon	This case was marked and excluded in this analysis					
19-Macknin&Mendend	This case was marked and excluded in this analysis					
20-Macknin&Mendend	This case was marked and excluded in this analysis					
21-Macknin&Mendend	-1.6688	-1.88 / -1.46	-.6419	.0000	-0.303	-7.563
22-Macknin&Mendend	-1.3812	-1.54 / -1.22	-.5691	.0000	-0.006	-0.006
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+3.513	-512.094
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-1.699	-206.028
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	+0.232	-3.166
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+1.125	-377.884
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-0.009	-0.024
28-DiGuiseppi-Port	-5.9948	-6.20 / -5.79	-.9487	.0000	-4.795	%-2121.479
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-0.671	-5.302
Overall:	-1.3753	-1.41 / -1.34	-.5666	.0000	3.279	-430.415

Note: Q(19)= 8286.510; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-3594.689 TWDS = 13230.37 TW = 2613.703
Largest outlier is DiGuiseppi-Portland

Qw(29) = 8286.510; p = 0.0000;
sums are: TWD =-3594.689 ; TWDS = 13230.37 ; TW = 2613.703 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 15:36:31, and these data were written to OUTPUT.DST. The raw effect sizes are stored in the file INTERVT1.DAT.

End-of-Output

Table G-12: Examination of Strategies to Promote Bicycle Helmet Usage: Only No Direct Intervention Entries Included

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	This case was marked and excluded in this analysis					
2-Dannenberg-Balt	-0.0389	-0.16 / +0.08	-.0195	.5131	+1.854	-812.225
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	-3.1551	-3.34 / -2.97	-.8450	.0000	-1.677	-301.655
5-DiGuiseppi	+0.2431	+0.06 / +0.43	+.1211	.0104	+1.958	-397.367
6-Kimmel&Nagel	-5.9137	-6.31 / -5.52	-.9476	.0000	-4.387	-471.393
7-Fullerton&Becke	+0.1896	-0.31 / +0.69	+.0968	.4506	+1.796	-49.307
8-Ruch-Ross&O'Con	-1.4139	-1.50 / -1.32	-.5775	.0000	+0.242	-19.995
9-Weiss-HighSchoo	+8.0350	+7.03 / +9.04	+.9710	.0000	+9.646	-353.153
10-Weiss-College-N	+5.1733	+4.70 / +5.65	+.9333	.0000	+6.831	-797.459
11-Pendergrast-Lit	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	+19.6599	+18.68 /+20.64	+.9949	.0000	+21.299	%-1794.270
13-Cote-HowardCo	This case was marked and excluded in this analysis					
14-Cote-BaltimoreC	+2.0898	+1.52 / +2.66	+.7297	.0000	+3.705	-163.174
15-Cote-Montgomery	This case was marked and excluded in this analysis					
16-Dannenberg2-Bal	-2.6096	-2.72 / -2.50	-.7939	.0000	-1.265	-432.630
17-Dannenberg2-How	This case was marked and excluded in this analysis					
18-Dannenberg2-Mon	This case was marked and excluded in this analysis					
19-Macknin&Mendend	This case was marked and excluded in this analysis					
20-Macknin&Mendend	This case was marked and excluded in this analysis					
21-Macknin&Mendend	-1.6688	-1.88 / -1.46	-.6419	.0000	-0.083	-0.555
22-Macknin&Mendend	-1.3812	-1.54 / -1.22	-.5691	.0000	+0.228	-6.960
23-Puczynski&Marsh	This case was marked and excluded in this analysis					
24-Liller	This case was marked and excluded in this analysis					
25-Rouzier&Alto	This case was marked and excluded in this analysis					
26-Rivara	This case was marked and excluded in this analysis					
27-DiGuiseppi-Seat	This case was marked and excluded in this analysis					
28-DiGuiseppi-Port	-5.9948	-6.20 / -5.79	-.9487	.0000	-4.663	%-1967.155
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	-2.0433	-2.61 / -1.47	-.7222	.0000	-0.456	-2.447
Overall:	-1.5900	-1.64 / -1.54	-.6223	.0000	4.006	-504.650

Note: Q(14)= 7171.436; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-2749.338 TWDS = 11542.9 TW = 1729.138
Largest outlier is DiGuiseppi-Portland

Qw(29) = 7171.436; p = 0.0000;
sums are: TWD =-2749.338 ; TWDS = 11542.9 ; TW = 1729.138 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-01-1997 at 15:34:27,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

APPENDIX H

EXAMINATION OF STRATEGIES TO PROMOTE BICYCLE HELMET USAGE: BEACHWOOD, OHIO ENTRY EXCLUDED

Table H-1: Examination of Strategies to Promote Bicycle Helmet Usage: Legislation Only Entries Excluding Beachwood

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.739	-537.634
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	-0.162	-0.638
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	This case was marked and excluded in this analysis					
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-1.139	-296.806
18-Dannenberg2-Mon	This case was marked and excluded in this analysis					
19-Macknin&Mendend	This case was marked and excluded in this analysis					
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	-0.389	-17.318
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	This case was marked and excluded in this analysis					
24-Liller	This case was marked and excluded in this analysis					
25-Rouzier&Alto	This case was marked and excluded in this analysis					
26-Rivara	This case was marked and excluded in this analysis					
27-DiGuiseppi-Seat	This case was marked and excluded in this analysis					
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	This case was marked and excluded in this analysis					
Overall:	-0.1959	-0.26 / -0.13	-.0975	.0000	0.857	-213.099

```
Note: Q(3)=    542.168; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
      sums are: TWD =-183.464  TWDS = 578.0999  TW = 936.7375
 Largest outlier is Dannenberg-HowCo
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```
Qw( 29 ) =    542.168; p = 0.0000;
      sums are: TWD =-183.464 ; TWDS = 578.0999 ; TW = 936.7375 .
      Dev.= deviation of d from the mean d excluding d.
      The marginal for Dev. is the average absolute deviation.
      Homo.= amount of reduction to Qw if effect size removed.
      The marginal for Homo. is average reduction per effect size.
      This table was created using DSTAT 1.11 on 10-02-1997 at 11:29:06,
      and these data were written to OUTPUT.DST.  The raw effect sizes
      are stored in the file INTERVT1.DAT.
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End-of-Output

Table H-2: Examination of Strategies to Promote Bicycle Helmet Usage: Legislation Only Entries (Excluding Beachwood) AND Joint Education and Community Entries

Intervention-Helmet Use Data Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.917	-761.024
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	This case was marked and excluded in this analysis					
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	This case was marked and excluded in this analysis					
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.215	-1.141
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	This case was marked and excluded in this analysis					
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-0.162	-9.973
18-Dannenberg2-Mon	This case was marked and excluded in this analysis					
19-Macknin&Mendend	This case was marked and excluded in this analysis					
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	+0.039	-0.187
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	+2.0814	+1.78 / +2.38	+.7231	.0000	+2.709	-302.271
24-Liller	-3.0268	-3.26 / -2.80	-.8349	.0000	-2.565	-463.691
25-Rouzier&Alto	-1.1485	-1.40 / -0.90	-.5000	.0000	-0.603	-21.164
26-Rivara	-0.3981	-0.50 / -0.29	-.1954	.0000	+0.206	-11.779
27-DiGuiseppi-Seat	-1.3829	-1.49 / -1.28	-.5691	.0000	-1.023	-305.686
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	This case was marked and excluded in this analysis					
30-Weiss-Elem-B to	This case was marked and excluded in this analysis					
Overall:	-0.5649	-0.61 / -0.52	-.2718	.0000	1.049	-208.546

Note: Q(8)= 1684.418; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
sums are: TWD =-1028.815 TWDS = 2265.573 TW = 1821.303
Largest outlier is Dannenberg-HowCo

Qw(29) = 1684.418; p = 0.0000;
sums are: TWD =-1028.815 ; TWDS = 2265.573 ; TW = 1821.303 .
Dev.= deviation of d from the mean d excluding d.
The marginal for Dev. is the average absolute deviation.
Homo.= amount of reduction to Qw if effect size removed.
The marginal for Homo. is average reduction per effect size.
This table was created using DSTAT 1.11 on 10-02-1997 at 00:55:23,
and these data were written to OUTPUT.DST. The raw effect sizes
are stored in the file INTERVT1.DAT.

End-of-Output

Table H-3: Examination of Strategies to Promote Bicycle Helmet Usage: Legislation only Entries EXCLUDING Beachwood AND Education Only Entries

Intervention-Helmet Use Data   Intervention ES's for Comparisons

Study	d	95% CI	r	p	Dev.	Homo.
1-Dannenberg-HowC	+1.1008	+0.97 / +1.23	+.4827	.0000	+1.987	-814.537
2-Dannenberg-Balt	This case was marked and excluded in this analysis					
3-Dannenberg-Mont	+0.0461	-0.04 / +0.14	+.0231	.3139	+0.910	-288.488
4-Wasserman	This case was marked and excluded in this analysis					
5-DiGuiseppi	This case was marked and excluded in this analysis					
6-Kimmel&Nagel	This case was marked and excluded in this analysis					
7-Fullerton&Becke	This case was marked and excluded in this analysis					
8-Ruch-Ross&O'Con	This case was marked and excluded in this analysis					
9-Weiss-HighSchoo	This case was marked and excluded in this analysis					
10-Weiss-College-N	This case was marked and excluded in this analysis					
11-Pendergrast-Lit	-5.7923	-6.26 / -5.33	-.9457	.0000	-5.225	-478.835
12-Pendergrast-Lit	This case was marked and excluded in this analysis					
13-Cote-HowardCo	-0.3532	-0.74 / +0.04	-.1765	.0746	+0.270	-1.800
14-Cote-BaltimoreC	This case was marked and excluded in this analysis					
15-Cote-Montgomery	-3.1128	-3.52 / -2.70	-.8431	.0000	-2.527	-145.321
16-Dannenberg2-Bal	This case was marked and excluded in this analysis					
17-Dannenberg2-How	-0.6790	-0.76 / -0.59	-.3216	.0000	-0.086	-2.782
18-Dannenberg2-Mon	-2.3934	-2.50 / -2.28	-.7676	.0000	-2.151	%-1186.665
19-Macknin&Mendend	This case was marked and excluded in this analysis					
20-Macknin&Mendend	-0.5289	-0.70 / -0.36	-.2563	.0000	+0.097	-1.176
21-Macknin&Mendend	This case was marked and excluded in this analysis					
22-Macknin&Mendend	This case was marked and excluded in this analysis					
23-Puczynski&Marsh	This case was marked and excluded in this analysis					
24-Liller	This case was marked and excluded in this analysis					
25-Rouzier&Alto	This case was marked and excluded in this analysis					
26-Rivara	This case was marked and excluded in this analysis					
27-DiGuiseppi-Seat	This case was marked and excluded in this analysis					
28-DiGuiseppi-Port	This case was marked and excluded in this analysis					
29-Weiss-Elem-A	-1.9840	-2.62 / -1.34	-.7143	.0000	-1.372	-17.575
30-Weiss-Elem-B to	This case was marked and excluded in this analysis					
Overall:	-0.6190	-0.67 / -0.57	-.2957	.0000	1.625	-326.353

```
Note: Q(8)=  2534.638; p = 0.0000;
d's are positive for differences in the Helmet Users direction.
effect sizes corrected for bias.
      sums are: TWD =-1098.574  TWDS = 3214.691  TW = 1774.664
 Largest outlier is Dannenberg2-MontgomeryCo

Qw( 29 ) =  2534.638; p = 0.0000;
      sums are: TWD =-1098.574 ; TWDS = 3214.691 ; TW = 1774.664 .
      Dev.= deviation of d from the mean d excluding d.
      The marginal for Dev. is the average absolute deviation.
      Homo.= amount of reduction to Qw if effect size removed.
      The marginal for Homo. is average reduction per effect size.
      This table was created using DSTAT 1.11 on 10-02-1997 at 00:57:26,
      and these data were written to OUTPUT.DST.  The raw effect sizes
      are stored in the file INTERVT1.DAT.

End-of-Output
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VITA

The author, Geraldine A. Brown, was born in Pottstown, Pennsylvania, the daughter of Patricia A. and the late Gerald E. Brown, Jr.

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Ms. Brown is a member of various academic and professional societies including the National Honor Society of Secondary Schools, Sigma Theta Tau International Nursing Honor Society, and the American Association of Neuroscience Nurses. She has also received several academic honors including the American Business Club Award for outstanding scholastic achievement, the Doe Club Award for Nursing, Dean's List Honors - Allentown College, the Medical College of Wisconsin Biostatistics Tuition Waiver Scholarship, and a graduate and teaching assistantship at

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Professionally, Ms. Brown has several years of clinical research experience in cardiovascular, orthopedic, and neurovascular nursing. She had designed, managed, coordinated, implemented, and analyzed various clinical research studies sponsored both by the pharmaceutical industry and private funds in multiple health disciplines. In addition, she has designed and maintained several clinical databases, and served as a liaison between physicians, statisticians and administration. She has also served as a research consultant and resource for young investigators, residents, allied health, and graduate students seeking to conduct research studies.

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DISSERTATION APPROVAL SHEET

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctorate of Philosophy in Research Methodology.

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