DISSERTATION

IDENTIFYING FACTORS ASSOCIATED WITH BICYCLE HELMET USE BEHAVIOR AMONG COLLEGE STUDENTS

Submitted by

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY ITSUMI KAKEFUDA ENTITLED IDENFITYING FACTORS ASSOCIATED WITH BICYCLE HELMET USE BEHAVIOR AMONG COLLEGE STUDENTS BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHYLOSOPHY.

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ABSTRACT OF DISSERTATION

IDENTIFING FACTORS ASSOCIATED WITH
BICYCLE HELMET USE BEHAVIOR AMONG COLLEGE STUDENTS

Traditional college age students belong to age groups which are at high risk of bicycle-related traumatic brain injuries and are known to be less likely to wear bicycle helmets compared to with other age groups. The study aimed to examine behaviors, attitudes, subjective norms, past bicycle helmet use, bicycle-related injury, and risk perceptions with regard to bicycle helmet use among student bicycle riders at Colorado State University. The long-term goal for the research is to develop bicycle helmet promotion programs targeted at this high risk group. A questionnaire was developed based on the Health Belief Model and the Theory of Reasoned Action, with the Stages of Change Model serving as a tool to classify bicycle riders into groups in accordance with current bicycle helmet use behaviors and future intentions to use.

A total of 315 responses were collected. The study included data from 199 students who used bicycles for commuting and for recreation in the 30 days preceding the date of survey. Among the student bicycle riders, 37% wore bicycle helmets every time for recreation; however only 9% used bicycle helmets for commuting. Differences in study variables among groups with different bicycle helmet use patterns were examined. Psychosocial factors associated with bicycle helmet use deferred between two bicycle use purposes, commuting and recreation. The analysis revealed that bicycle riders acknowledged the importance of bicycle helmet use in terms of traumatic brain injury prevention regardless of current bicycle helmet use and intentions to use helmets in the near future. However, bicycle helmet non-users and inconsistent users were less likely to think that they needed to wear bicycle helmets for short distance bicycle riding including commuting to school, compared to riders who wore bicycle helmets every time they rode.

Implications of the study suggest changes in methods currently used in bicycle helmet research. The study provided important information for the development of interventions among college-aged students.

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CHAPTER I

INTRODUCTION

Current health promotion programs encourage physical activity including bicycle riding to provide health benefits and decrease disease risk among U.S. populations of all ages (Centers for Disease Control and Prevention [CDC], 2007; U.S. Department of Health & Human Services [HHS], 2000). Bicycling has also been promoted in the U.S. as an alternative mode of transportation to "reduce motor vehicle emissions and improve the Nation's air quality" (Healthy People 2010, Chapter 8. Environmental Health. HHS, 2000).

Twenty percent or more of the U.S. population over age 18 rides bicycles (Bolen, Kresnow, & Sacks, 1998; Rodgers, 2000). In 1998, a sample of 3,347 U.S. households were contacted to estimate the number of bicycle riders (Rodgers, 2000). Based on survey results an estimated 85.3 million (31.6%) of the 270 million U.S. residents rode bicycles; 15.9 million (18.6%) were aged 16 to 24 years and 35.1 million (41.2%) were aged 25 years and older (Rodgers, 2000). In 1994, there were an estimated 38.1 million (20.2%) bicycle riders among adults aged 18 and older (Bolen et al., 1998). On average, bicycle riders aged 16 to 24 years rode 201 hours annually and riders aged 25 years and older rode 130 hours, while bicycle riders aged 15 years and younger rode about 300 hours annually (Rodgers, 2000). This represented a 27% increase in the number of bicycle rides between 1991 and 1998 (Rodgers, 2000).

In 1995, recreation accounted for 57% of bicycle rides (Pucher, Komanoff, & Schimik, 1999). Bicycle riding has been the seventh or eighth most popular recreational activity in the U.S. every year through 2000-2006 (National Sporting Goods Association, 2007), although the number participating has declined since 1992 (National Bicycle Dealers Association, 2006). Bicycling as a transportation mode increased from 0.6% in 1977 to 0.9% in 1995. In contrast, automobile use increased from 83.9% to 89.3%, walking decreased from 2.4% to 1.8%, and use of public transportation decreased from 9.3% to 5.5% (Pucher et al., 1999).

Between 1984 and 1988, about 900 to 1,000 bicycle riders in the U.S. died annually from injuries, and 2,985 (62%) of the total 4,812 deaths over the five years were due to traumatic brain injuries (TBIs) (Sacks, Holmgreen, Smith, & Sosin, 1991). Of the bicycle-related TBI deaths, 1,759 (58.9%) were bicycle riders aged 15 years and older. Annual numbers of deaths among bicycle riders aged 16 years and older have remained consistent at around 500 since the middle of 1980s, while the numbers declined among young bicycle riders from about 700 in the middle of 1970s to about 300 in the middle of 1990s (Pucher et al., 1999). Deaths among adult riders have exceeded deaths among child riders since 1986 (Pucher et al., 1999). During the 1980s, 65% of bicycle-related deaths were among adults aged 15 years and older (Sacks et al., 1991). In 2005, 640 (81.8%) of 782 bicycle-related deaths were among bicycle riders aged 16 years or older (Insurance Institute for Highway Safety, 2007).

Between 1984 and 1988, 905,752 (32.5%) of 2,789,678 bicycle-related non-fatal injuries were TBIs. Bicycle riders aged 15 years and older accounted for 216,495 (23.9%)

of the nonfatal TBI (Sacks et al., 1991). A more recent study estimated that 41.0 per 10,000 bicycle riders aged 16 years and older experienced bicycle-related injuries in 1998, while 116.7 per 10,000 bicycle riders younger than 16 years of age had injuries (Rodgers, 2000). Child bicycle riders had 2.85 times higher non-fatal injury rates compared to adult riders. After adjusting for differences in bicycle riding hours between age groups, the average injury rate for child bicycle riders younger than 16 years of age was only about 44% higher than bicycle riders 16 years of age and older (Rodgers, 2000). Adult bicycle riders may have a similar degree of susceptibility to nonfatal bicycle-related injury but have different exposure to risk based on frequency of bicycle riding.

Bicycle helmet use has been shown to be effective in preventing serious brain injury and death from TBI. A meta-analysis of 16 published studies reported that bicycle helmet use reduced head injury (all injuries to the head including face and skull) by 45%, brain injury (a subset of head injury including concussion with or without intracranial injury) by 33%, and fatal injury by 29% (Attewell, Glase, & McFadden, 2001). The meta-analysis and studies included in the analysis have been criticized for not taking into considerations types of brain injuries and effects of bicycle helmet on different brain injuries (Curnow, 2003). Curnow (2003) also argued that the meta-analysis ignored historical changes in bicycle helmet types and differences across helmet types in the effectiveness in preventing brain injuries: many of the studies included in the meta-analysis was conducted during 1980s when bicycle helmets were hard-shell and currently-common soft/micro-shell helmets were not yet available. However, at least one recent case-control study, which was included in the meta-analysis, reported that using bicycle helmet reduced risks of head injury, brain injury, and severe brain injuries regardless of types of bicycle helmets (i.e., hard-shell, soft-shell, or no-shell) (Thompson, Rivara, & Thompson, 1996).

Universal bicycle helmet use could prevent death, injury and sequelae and reduce medical costs. If all bicycle riders had worn helmets, approximately 327 deaths, 6,900 hospitalizations, and 100,000 emergency department visits caused by bicycle-related TBIs could have been prevented in 1997 in the U.S. (Schulman, Sacks, & Provenzano, 2002). Estimated direct and indirect medical costs for preventable injuries were $81 million and for deaths $2.3 billion excluding long-term care, home health care, pain and suffering, and other peripheral costs (Schulman et al., 2002)

Despite the effectiveness of bicycle helmet use in TBI prevention, bicycle helmet use rates among adults remain low. In one study, only 18.3% of adult bicycle riders aged 18 years and older reported consistent bicycle helmet use (Bolen et al., 1998). Another study estimated that 21.8% of bicycle riders aged 16 to 24 years wore bicycle helmets more than half of the time they rode bicycles, which was much lower than the bicycle helmet use rates of 58.9% among bicycle riders aged 15 years and younger and 42.0-47.7% among age groups older than 24 years of age (Rodgers, 2000). In a national observational study 39% of adult bicycle riders wore bicycle helmets (Cody, Quraishi, & Mickalide, 2004). However, bicycle helmet use rates varied depending on the location bicycle riders were observed; bicycle helmets were less frequently used on residential streets compared to use on bicycle paths and in parks (Cody et al., 2004).

Bicycle helmet use behaviors, knowledge, and attitudes among children and adolescents have been studied (DiGuiseppi, Rivara, & Koepsell, 1990; Gielen, Joffe, Dannenberg, Wilson, Belienson, & DeBoer, 1994; Howland, Sargent, Weitzman, Mangione, Ebert, Mauceri, & Bond, 1989; Lajunen & Räsänen, 2001; Lajunen & Räsänen, 2004; Liller & Morissette, 1998; Loubeau, 2000; Quine, Rutter, & Arnold, 1994). Interventions targeting children and adolescents have been conducted including school-based or community-based education, legislation, and helmet distribution for free or at reduced cost (Thompson, Sleet, & Sacks, 2002; Royal, Kendrick, & Coleman, 2005: Rivara, Thompson, Patterson, & Thompson, 1998). Research has been published about parental attitudes and behaviors regarding bicycle helmet use in association with children's bicycle helmet use (Bernstein, Harper, Pardi, & Christopher, 2003; Dannenberg, Cote, Kresnow, Sacks, Lipsitz, & Schmidt, 1993; DiGuiseppi et al., 1990; Ehrlich, Helmkamp, Williams, Haque, & Furbee, 2004; Ehrlich, Longhi, Vaughan, & Rockwell, 2001; Finnoff, Laskowski, Altman, & Diehl, 2001; Jones, King, Poteet-Johnson, & Wang, 1993; Khambalia, MacArthur, & Parkin, 2005; Miller, Binns, Christoffel, 1996; Ortega, Shields, & Smith, 2004). Increasing bicycle helmet use among adults has been identified as important, based on potential effects of adult bicycle helmet use behavior on children (Cody et al., 2004; Dannenberg et al., 1993; Ehrlich et al., 2001; Ehrlich et al., 2004; Finnoff et al., 2001; Khambalia et al., 2005; Rivara, Thompson, Thompson, Rogers, Alexander, Felix, & Bergman, 1994).

To date, few studies have examined bicycle helmet use behaviors and attitudes among adult populations independently from parent-child contexts: adult riders (McCoy, 2002; Wasserman, Waller, Monty, Emery, & Robinson, 1988); senior bicycle riders (Bungum & Bungum, 2003); and college students (Coron, McLaughlin, & Dorman, 1996; Everett, Price, Bergin, & Groves, 1996; Fullerton & Becker, 1991; Joly, McDermotto, & Westhoff, 2000; Patrick, Covin, Fulop, Calfas, & Lovato, 1997; Page, Follett, Scanlan, Hammermeister, & Friesen, 1996; Weiss, 1996; Weiss, Okun, & Quay, 2004). One intervention study targeting college students was published (Lutwig, Buchholz, & Clarke, 2005). Based on the significance of bicycle-related TBI among adult bicycle riders and the importance of increasing bicycle helmet use, more research on adult bicycle riders is needed. More specifically, college students are a group of adults for which more bicycle helmet-related research are necessary. A majority of college students belong to age groups which are most susceptible to bicycle-related TBI (Sacks et al., 1991), and were least likely to wear bicycle helmets among all age groups (Bolen et al., 1998; Rodgers, 2000). Increased bicycle helmet use among the group is likely to contribute to reducing mortality and morbidity of bicycle-related TBI.

College students and bicycle helmet use

Nine published papers were identified which examined bicycle helmet use, and associations between bicycle helmet use behaviors, attitudes and other factors among college students in the U.S. Bicycle helmet use varied across universities at which studies were conducted, from a low of 5.0% to a high of 26.7% without interventions, and to a high of 49.3% during an intervention. Studies are not comparable because each study examined associations using different variables and questionnaires. One paper has been identified which implemented an intervention program on campus. The studies are described in detail below.

A 1993 California statewide youth risk behavior survey found that 70.7% of undergraduate students of four-year colleges had ridden a bicycle in the past 12 months. Only 5.0% of the student bicycle riders reported that they always wore bicycle helmets, and 76.1% never wore bicycle helmets in the past 12 months. There was no difference between females and males in bicycle helmet use (Patrick et al., 1997).

A series of observational studies were conducted in 1985, 1990, and 1994 at the University of Arizona in Tucson to assess bicycle helmet use among college students and changes in the use over time (Weiss, 1996). Bicycle helmet use in 1994 was 40 of 150 (26.7%, CI: 19.0 - 36.2%) observed bicycle riders, which was higher than the 15 of 150 (10.0%, CI: 5.6 - 16.5%) in 1985 and then 10 of 225 (4.4%, CI: 2.1 - 8.1%) in 1990 (Weiss, 1996). No formal interventions had been implemented at the university between 1985 and 1994. The author suggested that two well-publicized incidents, the bicycle-related TBI death of a professor on campus in 1991 and enactment of a city ordinance in 1994 that required children in Tucson to wear bicycle helmets, might have increased awareness of the importance of bicycle helmet use among college students, leading to higher bicycle helmet use (Weiss, 1996). In addition, an upward trend in bicycle helmet use on a state or national level might have accounted for the higher use rate (Weiss, 1996).

Seventeen (17%) of 100 students surveyed at the University of New Mexico wore bicycle helmets 75% or more of the time they rode (Fullerton & Becker, 1991). During the year preceding the survey, 44 (44.0%) students sustained minor injuries from bicycle riding, and four of them (9.1%) were minor head injuries. Eighteen (18.0%) students reported hospitalization some time in their life due to bicycle-related injuries, and two had sustained head injuries. None of the students sustaining head injuries had worn bicycle helmets at the time of incident (Fullerton & Becker, 1991). Past injury experience, insurance coverage, and being non-Hispanic white were associated with bicycle helmet ownership; in contrast, there were no associations between helmet ownership and age, gender, marital status, whether students had children or not, major purpose for bicycle riding, weekly bicycle trip length in miles, percentage of time riding bicycle in heavy traffic and on bicycle trails, and, frequency of bicycle riding during rainstorms or in darkness (Fullerton & Becker, 1991). One third (34.5%) of bicycle helmet owners decided on helmet use based on anticipated bicycle trip length, and about 30% of bicycle helmet owners mentioned that cost and lack of comfort were downsides of bicycle helmet use (Fullerton & Becker, 1991).

Associations between bicycle helmet use and gender and residential status, differences in bicycle helmet use between students living on-campus facilities and off-campus facilities, were assessed at a university located in the southeastern U.S. (Joly et al., 2000). Among 483 respondents of a transportation safety survey 321 (66.5%) rode bicycles in the past 12 months, and 17 (5.4%) of the bicycle riders reported that they wore bicycle helmets more often than sometimes (Joly et al., 2000). There were no differences in bicycle helmet use between males and females and between two student groups residing in on-campus and off-campus housing (Joly et al., 2000).

Four other studies examined associations between bicycle helmet use/non-use and psychosocial variables. A study at a state university in the Pacific Northwest region examined perceived barriers to bicycle helmet use, risk perception regarding bicycle-related injury, social norms related to bicycle helmet use, and perception toward bicycle helmet use as a habit (Page et al., 1996). A total of 390 students were surveyed and 215 (56.0%) respondents who reported bicycle riding were included in the analysis. Of the bicycle riders, 106 (49.3%) were 'bicycle helmet non-users' who wore bicycle helmets

0% of the time they rode, 71 (33.0%) were 'infrequent users' wearing bicycle helmets 10 - 60% of the time, and 36 (16.7%) were 'frequent users' who wore bicycle helmets more than 70% of the time (Page et al., 1996). Helmet use was associated with reported bicycle trip length in miles (Page et al., 1996). Stepwise discriminant analysis revealed that perception toward bicycle helmet use as a habit, represented by a question "Wearing a bicycle helmet while bicycling is a habit for me" was the most significant item in differentiating three different bicycle helmet use groups; another habit perception question "Wearing a bicycle helmet is something I never think of" was the second (Page et al., 1996). For all riders, three other questions, "Wearing a bicycle helmet is impossible for me because purchasing a helmet is too expensive," "… impairs my vision" and "… messes up my hair," were selected as statistically significant discriminant variables (Page et al., 1996). For female riders, two other questions, "Wearing a bicycle helmet impairs my vision" and "… messes up my hair," and for male riders, one question "Wearing a bicycle helmet is not necessary if you are a good rider" were the next most significant variables following the two habit questions (Page et al., 1996).

Bicycle helmet use behaviors and reasons of bicycle helmet use/non-use were examined among undergraduate students at the University of Florida (Coron et al., 1996). Fifty (18.4%) of 272 undergraduate student bicycle riders wore bicycle helmets. Of bicycle helmet users 72% had received a recommendation from others to wear a helmet, while only 55% of non-users had. Seventy-four percent of bicycle users had friends who also wore bicycle helmets; in contrast, 33% of non-users had friends who were bicycle helmet users. Regarding bicycle-related injury experience, 66% of bicycle helmet users had friends with injury experience, while only 48.2% of bicycle helmet non-users had friends with injury experience (Coron et al., 1996).

A study conducted at three universities located in the Midwestern region examined bicycle helmet use from the perspective of personal goal achievement (Everett et al., 1996). Of 241 bicycle riders who were younger than 30 years of age, 20% considered themselves ‘helmet wearers’ (Everett et al., 1996). Knowing people who were injured in bicycle-related incidents and having many friends who wore bicycle helmets were associated with bicycle helmet use among respondents; in contrast, gender, race, frequency of bicycle riding, personal injury history, and year in school were not related to bicycle helmet use (Everett et al., 1996). Bicycle helmet wearers differed from non-wearers in responses to most of 30 bicycle-helmet attitude, belief, and norm questions, which were categorized into eight ‘goal subscales’ including positive evaluations, safety, material gain, and social responsibility (Everett et al., 1996). Scores on the goal subscales were consistently higher among helmet wearers than non-wearers; authors concluded that bicycle helmet use behaviors were associated with achievement to multiple goals (Everett et al., 1996).

Differences in bicycle helmet use behavior, attitudes toward bicycle helmet use, and knowledge about bicycle safety were examined among three different age groups (Weiss et al., 2004). The groups were: middle school students (seventh grade) and high school students (ninth grade) of Phoenix, Arizona, and undergraduate students of the Arizona State University who comprised 41% of 797 respondents (Weiss et al., 2004). Bicycle helmet use behaviors were defined using the Stages of Change (Transtheoretical) Model (Grimley, Prochaska, Velicer, Blais, & DiClemente, 1994; Prochaska & DiClemente, 1983). Among all students, 43% did not wear bicycle helmets and did not have an intention to wear one (Precontemplation stage), 17% did not wear bicycle helmets currently but expressed an intention to wear one in the near future (Contemplation and Preparation stages), 16% wore bicycle helmets (Action and Maintenance stages), and 24% had worn bicycle helmets in the past but not at the time of the survey (Relapse stage) (Weiss et al., 2004).

The three age groups were compared using multinominal logistic regression analysis (Weiss et al., 2004). College students were less likely to use bicycle helmets compared to middle school and high school students (Weiss et al., 2004). Comparing students at Precontemplation to those at Contemplation, students who were more knowledgeable about bicycle safety were more likely to express the intention of bicycle helmet use in the near future controlling for the effect of age (Weiss et al., 2004).

An intervention program was developed and applied at a university in the southeastern region aiming to increase bicycle helmet use (Lutwig et al., 2005). The intervention used a social marketing approach, a strategy to 'sell' a desired behavior to a target consumer group by reducing the impact of competing behaviors (i.e., bicycle helmet non-use) and barriers to committing a desired behavior (i.e., bicycle helmet cost and peer disapproval) (Lutwig et al., 2005). Fifteen bicyclists who were trained recruited bicyclists willing to make a pledge to wear a bicycle helmet in return for a coupon for a free helmet (Lutwig et al., 2005). The program did not distribute free bicycle helmets directly to participants at the time of pledge; instead, students had to go to a specific store to redeem the coupon (Lutwig et al., 2005). This was based on a finding that the effect of distributing free bicycle helmets on increasing bicycle helmet use might be temporary, or might not be effective among older children (Logan, Leadbetter, Gibson, Scheiber, Branche, Bender, Zane, Humphreys, and Anderson, 1998). The authors assumed that making the effort to obtain a bicycle helmet would motivate a bicycle rider to wear the free helmet (Lutwig et al., 2005).

During the five week intervention, a total of 379 pledge cards were received from bicycle riders and 242 free bicycle helmet coupons were redeemed (Lutwig et al., 2005). Observed bicycle helmet use on the university campus increased from an average of 26.1% during the weeks before the intervention up to an average of 49.3% during intervention, and remained at an average of 44.4% during three weeks after the program (Lutwig et al., 2005). In contrast, bicycle helmet use at the control university was stable around 12-14% over the study period (Lutwig et al., 2005).

Bicycle helmet use and psychosocial variables

Bicycle helmet use behavior

To assess associations between bicycle helmet use behaviors and psychosocial variables, bicycle helmet use needs to be classified. Eight of nine college student bicycle helmet papers identified for this literature review asked respondents whether they wore bicycle helmets or how often they wore them. One study (Weiss et al., 2004) and a previous study conducted in Fort Collins (Kakefuda, 2006; Kakefuda et al., in press) used a framework of the Stages of Change model to classify bicycle helmet use behaviors. The Stages of Change model (Grimley et al., 1994; Prochaska & DiClemente, 1983) is a tool to classify individual behaviors based on current behaviors and intentions to commit a preventive behavior (e.g., wearing a bicycle helmet, quitting smoking) in the near future. Behavioral intention has been considered a mediator of attitude and actual behavior, suggesting the importance of measuring intentions of commuting target behaviors (Kim & Hunter, 1993). The model includes five stages, which are defined by a current behavior and an intention to change an existing behavior (Grimley et al., 1994). These stages are: Precontemplation; Contemplation; Preparation; Action; and Maintenance (Table 1).

Table 1

*Stages of Change Identified in the Stages of Change Model**

Stage	Definition
Precontemplation	No intention to change their problem behavior in the foreseeable future, within the next six months
Contemplation	Awareness of the problem. Serious intention to change the behavior within the next six months
Preparation	Intention to take action in the near future, usually the next month
Action	Overt behavioral changes occurred within the past six months
Maintenance	A period ranging from six months after the behavior changed

* Grimley et al., 1994

The model has been used in health behavior research (Prochaska, Redding, & Evers, 2002), and may be useful for bicycle helmet research to assess differences across groups who present different bicycle helmet use behaviors, and also groups who present the same behavior (e.g., bicycle helmet non-use) but express different behavioral intentions (e.g., no intention to wear bicycle helmet vs. an intention to start wearing bicycle helmet in the near future) (Kakefuda, 2006; Kakefuda, Stallones, & Gibbs, in press; Weiss et al., 2004).

A semi-qualitative bicycle helmet study was conducted in Fort Collins between 2004 and 2005 targeting adults working or living in the community; the study used the framework of the Stages of Change to classify bicycle riders in accordance with current behaviors and future intentions (Kakefuda, 2006; Kakefuda et al., in press). CSU students (n=13) were all frequent bicycle riders; however, only five students (38.5%) were at Maintenance stage, two (15.4%) were at Preparation, and six (46.2%) were at Precontemplation stage. In contrast, 27 (62.8%) of 43 other adult bicycle riders in the community were at Maintenance stage.

The study indicated the utility of the Stages of Change model with regard to including behavioral intentions in addition to current behaviors for classification (Kakefuda, 2006). Adult bicycle riders at different stages presented significant differences in attitudes toward bicycle helmet use; riders at the higher stages were more positive toward use compared to riders at lower stages (Kakefuda, 2006). The difference was significant even between two stage groups, Precontemplation and Contemplation; one group who expressed no intention to consistently wear bicycle helmets irrespective of current bicycle helmet use, and the other who expressed the intention despite current no or rare use of bicycle helmets (Kakefuda, 2006). Riders with intentions to consistently wear bicycle helmets presented more positive attitudes toward use than those with no intention to do so in the future (Kakefuda, 2006). In the case of bicycle helmet use behavior, non-helmet users may vary in intentions to wear bicycle helmet and a group of non-users with a high level of intention may have more willingness to change the behavior compared to another group of non-users who also did not wear bicycle helmets but express a lower level of intention. Intentions of bicycle helmet use may be also associated with other variables than attitudes, such as past experiences related to bicycle riding and helmet use, subjective norms of others, and perceptions toward risk. The classification by the Stages of Change model has a potential to provide detailed information of students with different bicycle helmet use and intentions, which is helpful for tailoring group-specific intervention programs. Considering limited resources available to develop and implement intervention programs and the importance to use effective programs to change behaviors, promotional efforts should start with a group which is “most ready to change their behavior” (Parvanta, 2000); even if the group is not the group most in need of intervention (Forthofer, 2000).

Bicycle helmet use behavior may vary depending on purposes of bicycle riding, for example, whether they ride bicycle for commuting or for recreation (Cody et al., 2004). Bicycle trip length may be also associated with bicycle helmet use. (Page et al., 1996). In a previous study of adult bicycle riders in Fort Collins, none of bicycle riders who wore bicycle helmets every time they rode agreed with the statement “When riding around home or short distances, I do not need to wear a helmet,” while 6 of 10 (60.0%) riders who did not wear bicycle helmets agreed the statement (Kakefuda, 2006).

Attitudes toward bicycle helmet use

In a previous study of adult bicycle riders in Fort Collins, all interviewees agreed with the statement: “In your opinion, in the event of an accident, is a person wearing a helmet less likely to have a head injury than those without a helmet?” (Kakefuda, 2006). Bicycle riders understand the effectiveness of a bicycle helmet in preventing TBI. Nevertheless, 40% of college student bicycle riders interviewed in the study did not wear bicycle helmets (Kakefuda, 2006). Acknowledging the effectiveness of bicycle helmets did not correlate directly with personal use. Other studies reported the similar results; many adult bicycle riders did not wear bicycle helmets although they thought that a bicycle helmet would protect the head (Page et al., 1996; Wasserman et al., 1988).

There are other attitudinal factors associated with bicycle helmet use among college students: cost of purchasing a bicycle helmet; a concern about messing up their hair; and cumbersomeness of carrying helmet around campus (Coron et al., 1996; Fullerton & Becker, 1991; Page et al., 1996). Students were less likely to wear bicycle helmets when they perceived the factors as barriers to bicycle helmet use (Coron et al., 1996; Fullerton & Becker, 1991; Page et al., 1996).

Attitudes toward bicycle helmet use may be multi-dimensional with cognitive evaluations including bicycle helmet utility in TBI prevention, affective reactions to the behavior, and others. Semantic differential (Osgood, 1952; Snider & Osgood, 1969) may be used to assess the dimensionality and provide detailed information regarding college student attitudes toward bicycle helmet use. Semantic differential posits that people's attitudes toward a target are multi-dimensional, not one dimensional which can be measured by unipolar or bipolar scales (Osgood, 1952). The technique uses multiple sets of adjectives to assess attitude structures (Osgood, 1952). For instance, early semantic differential studies of stereotyping to other nationalities reported that each nationality was placed in a unique location defined by three dimensions; evaluation (e.g., Bad-Good), potency (e.g., Strong-Weak), and activity (e.g., Active-Passive) (e.g., Prothro & Keehn, 1957). Exploring the dimensionality of bicycle helmet use attitudes may guide intervention program development through selection of specific dimensions to address.

Attitudes among a target group toward bicycle helmet promotion efforts also need to be addressed as well as attitudes toward bicycle helmet use behaviors. A bicycle helmet intervention can be educational, legislative, or a combination of both. However, college students and universities may not be supportive of legislative efforts on campus (Joly et al., 2001; Lutwig et al., 2005). In a previous study in Fort Collins, multiple participants described a community climate as being favorable to educational bicycle helmet promotions and less favorable to legislative efforts, suggesting that climate of the community preferred to leave a decision of bicycle helmet use to individuals (Kakefuda, 2006). Exploring attitudes among college students toward a legislative approach such as implementing a campus bicycle helmet policy will provide information about student view of this approach.

Past bicycle helmet use experiences

Bicycle safety education during primary education, and state and local laws and ordinances requiring child bicycle riders to wear bicycle helmets have been shown to increase bicycle helmet use among the populations (Rivara et al., 1998; Rodgers, 2002; Royal et al., 2005). However, high school and college students, who were 16-24 years of age, were more likely to be non-users (71.6%), compared with adults aged 25- 34 years (48.0%) and children aged 15 years and younger (19.3%) (Rodgers, 2000). Establishing the habit of bicycle helmet use during early childhood may be susceptible to peer social pressure as children get older. Peer norms regarding bicycle helmet use tended to have a stronger influence on older children and adolescents than parental rules and attitudes, and older children were less likely to use bicycle helmets because of negative attitudes toward bicycle helmets among peers (Howland et al., 1989; Liller & Morissette, 1998; Loubeau, 2000).

Effects of past behaviors (i.e., habit) on current behaviors have been discussed in the Theory of Reasoned Action (TRA. Ajzen & Fishbein, 1980) and the Theory of

Planned Behavior (Ajzen, 1991) to expand the utility of the models (Ajzen & Fishbein, 2000). For example, O'Callaghan & Nausbaum (2006) found in two surveys conducted with two-week interval that bicycle helmet use among high school students at the second survey were correlated with use reported at the first survey. A correlation between past behaviors and current behaviors was reported seat belt use research targeting college students (Budd, North, & Spencer, 1984; Wittenbraker, Gibbs, & Kahle, 1983). The studies only examined associations between times close to each other, i.e., two weeks. Long-term effects of bicycle helmet use, such as effects of use during childhood on use in college age, has not been examined.

Perceived norm

Perceived norm is a construct first introduced in the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and has been used in many areas of research (Montaño & Kasprzyk, 2002). Ajzen and Fishbein (1980) defined the construct of perceived norm as "the person's perception that important others desire the performance or nonperformance of a specific behavior" (p.57). The theory postulates that an individual behavioral intention will be higher when the person perceives important others to want him or her to commit the behavior compared to when the person perceives others' expectations to be low.

Bicycle helmet use among peers was associated with bicycle helmet use among college bicycle riders (Coron et al., 1996). Sixty-seven percent of frequent bicycle helmet users among college students agreed with the statement, "Wearing a bicycle helmet while cycling is characteristic of most of my friends"; in contrast, only 22.5% of infrequent users and 12.4% of non-users agreed with the statement (Page et al., 1996). Bicycle helmet users had more friends who wore bicycle helmets compared to bicycle helmet non-users (Everett et al., 1996). An observational study found concordance in bicycle helmet use with peer riders among adult bicycle riders (Dannenberg et al., 1993). Observed concordance of bicycle helmet use among 277 pairs of adult riders was 87%: among pairs observed, both riders in 115 pairs used helmets, neither in 127 did, with only 35 pairs discordant in helmet use (Dannenberg et al., 1993).

Expectations of parents and family may be also associated with bicycle helmet use behaviors among college students. More than 70% of frequent bicycle helmet users among college students agreed with a statement "Wearing a bicycle helmet while bicycling is encouraged by my parents/family," while only 40.0% of non-users agreed with the statement (Page et al., 1996). Another study asked students about perceptions toward family norm with a different wording, "My family would be supportive of my wearing a bicycle helmet," and did not find a difference between bicycle helmet users and non-users (Everett et al., 1996).

A community may set a certain norm regarding safety. Weiss (1996) suggested that an increase observed on the University of Arizona campus in bicycle helmet use rates from 4.4% in 1990 to 24% in 1994 might be due in part to the city ordinance enacted at the beginning of 1994 which required child bicycle riders in Tucson to wear bicycle helmets.

The study community, Fort Collins, may have climate supportive of bicycle helmet use. An observed bicycle helmet use rate among adults in Fort Collins was 48% (Institute of Transportation management, Colorado State University, 2004), higher than the rate obtained in a national observational study, which was 39% (Cody et al., 2004).

The nationwide study included communities with or without laws or ordinances which required youth or all bicycle riders to wear bicycle helmets (Cody et al., 2004). Fort Collins as well as any communities in Colorado and the state itself do not have any bicycle helmet laws or ordinances as of January 1, 2008 (Bicycle Helmet Safety Institute, 2008). Reasons of the high bicycle helmet use in Fort Collins are unknown; however, the community may have forged a supportive climate for bicycle helmet use in the history of bicycle promotion. The city has been recognized as a bicycle friendly community (League of American Bicyclists, 2003 & 2005) because the city has developed the infrastructure including bicycle lanes on city streets, bicycle trails, and bicycle racks for public use, to increase bicycle use. The city also has developed the promotion program for alternative transportation (SmartTrip™. City of Fort Collins, 2007), which includes bicycle-related safety information including the importance of bicycle helmet use. The environment might create a community norm which encourages residents to voluntarily wear bicycle helmet.

A previous study conducted in Fort Collins (Kakefuda, 2006; Kakefuda et al., in press) assessed the community's readiness to address the issue of bicycle helmet use with the Community Readiness model (Oetting, Donnermeyer, Plested, Edwards, Kelly, & Beauvais, 1995; Oetting, Jumper-Thurman, Plested, and Edwards, 2001). The model evaluate six dimensions of community readiness including community's knowledge of bicycle helmet promotion, community resources to address the issue, leadership involvement, and perceptions toward community climate (Oetting et al., 2001). CSU students interviewed in the study did not know any of community bicycle helmet promotion efforts except a bicycle registration policy on campus, while many non-student residents of Fort Collins knew the programs and other efforts targeting children (Kakefuda, 2006). CSU students might not perceive bicycle safety climate in the community to be positive, leading less frequent bicycle helmet use compared to other community residents.

Perceptions toward risk and control

People tend to perceive the probability of a negative event lower than the objective probability of the event, and perceive their own susceptibility to a negative event lower compared to the susceptibility of others. This psychological mechanism is called optimistic bias or unrealistic optimism (Weinstein, 1980). This bias applied to traffic-related events (DeJoy, 1989; Rutter, Quine, & Albery, 1998; Weinstein, 1980). Individuals who were more optimistic regarding traffic-related injuries were less likely to use safety equipment and those who perceived their own susceptibility to be high were more likely to use safety equipment in relation to bicycle helmet use among children and adults (Wasserman et al., 1988), seat belt use (Weinstein, Grubb, & Vautier, 1986), and child restraint seat use (Simpson, Moll, Kassam-Adams, Miller, & Winston, 2002). Health behavior research has used similar constructs, perceived vulnerability and perceived severity, in the Health Belief Model (HBM. Janz, Champion, & Strecher, 2002; Rosenstock, 1974). To date, three studies applied HBM to bicycle helmet use behavior among school aged children (Gielen et al., 1994; Lajunen & Räsänen, 2004; Quine et al., 1994). One study reported an inverse association between risk perception and bicycle helmet use; higher perceived risk was associated with lower bicycle helmet use among children in two of three counties (Gielen et al., 1994).

Perception toward risk is moderated by belief in personal control over an event

(Helweg-Larsen & Shepperd, 2001; Klein & Helweg-Larsen, 2002). When a bicycle rider believes that he or she is a skilled rider and can avoid injury events, the control belief may increase optimistic bias toward susceptibility of bicycle-related injury, leading to lower perceived risk of injury. Personal control belief and its association with optimistic bias and risk perception related to bicycle helmet use behaviors have not been reported in published papers. Prior experiences of negative events have been consistently associated with less optimistic bias toward the risk of the events (Helweg-Larsen & Shepperd, 2001). Injury experiences of self and others were associated with bicycle helmet use among college students (Coron et al., 1996; Fullerton & Becker, 1991).

Summary of literature

In summary, college students are an excellent target group for bicycle helmet intervention programs because a majority of them did not wear bicycle helmet (Coron et al., 1996; Everett et al., 1996; Fullerton & Becker, 1991; Joly et al., 2000; Kakefuda, 2006; Lutwig et al., 2005; Patrick et al., 1997; Page et al., 1996; Weiss, 1996; Weiss et al., 2004). CSU students meet the criteria to identify a target group of intervention (Institute of Medicine [IOM], 2002). They were found to be frequent bicycle riders, but to be less likely to wear bicycle helmets compared to other adult groups of the community (Kakefuda, 2006). The bicycle and bicycle helmet use behaviors expose CSU student bicycle riders to high Epidemiological risk on mortality and morbidity by bicycle-related TBIs: the number of CSU students is 24,670 (Office of Budgets and Institutional Analysis at CSU [OBIA], 2006) and a majority of them belong to age groups which are most susceptible to bicycle-related TBIs (Sacks et al., 1991). The size of a group of people who could benefit from an intervention is large: the entire CSU student population accounts for about 18.0% of the city population (OBIA, 2006). Accessibility of the student population is high because CSU students use a single main campus: an intervention could use the campus to deliver messages and communicate with students.

To develop and apply an effective and efficient intervention program, it is important to understand characteristics of a target group. In the case of CSU students, bicycle helmet use behaviors and attitudes toward bicycle helmet use were not homogenous: some students wore bicycle helmets and others did not; some had intentions to wear bicycle helmets and others did not; and, some had positive attitudes toward bicycle helmet use and others' attitudes were less positive (Kakefuda, 2006). Psychosocial determinants such as knowledge, attitudes, and interactions within social environments (e.g., friends, family, neighborhood) need to be identified to select target groups and to tailor intervention strategies (Slater, 1996). Different intervention programs are necessary for sub-groups with different behaviors, behavioral intentions, and attitudes because readiness of groups and individuals to a change varies (Grimley et al., 1994; Oetting, et al., 2001).

Findings in literature provided a strong rationale for a study to identify groups of CSU students with different bicycle helmet use behaviors and understand characteristics of groups from the perspectives of intervention program development. The study therefore assessed bicycle-related behaviors and attitudes using variables which appeared in previous bicycle helmet studies of college students and other variables (e.g., past bicycle helmet use, perceived norm of a community) which had not been used in the bicycle helmet studies of college students but might be important according to other safety-related studies.

Research questions

The purpose of the study was to examine bicycle helmet use behaviors among Colorado State University (CSU) students and associations between bicycle helmet use behaviors and psychosocial variables related to bicycle helmet use and/or other traffic safety behaviors. The psychosocial variables include: attitudes toward bicycle helmet use; past bicycle helmet use experiences; perceptions toward risk and personal control; injury experiences; and, perceived norms. Associations between bicycle helmet use and the psychosocial variables might vary depending on current bicycle use patterns including purposes of bicycle use and trip length, and demographic characteristics of bicycle riders.

The study focused on describing characteristics of student bicycle riders at CSU with different bicycle helmet use behaviors and behavioral intentions to use bicycle helmets. Based on findings in literature, directions of associations between bicycle helmet use behaviors and psychosocial variables were hypothesized. More frequent bicycle helmet use was proposed to be associated with:

- Positive attitudes (evaluative and emotional attitudes) toward bicycle helmet use and bicycle helmet promotion efforts,
- More frequent bicycle helmet use in the past,
- Higher perceived risk of bicycle-related head injuries,
- Lower perceived personal control as a bicycle rider on the road,
- Injury experiences by oneself and people a respondent knew, and,
- Perceived positive norms of others.

CHAPTER II

METHODS

Participants of the study

Participants of the study were students of Colorado State University (CSU) who had ridden bicycles during the 30 days preceding the date of survey.

Procedure

During April 2007, data collection was conducted at the plaza in front of the student center of the university. The investigator and other graduate students trained in the data collection procedure invited students who had ridden bicycles during the past 30 days to participate in the study. A sign was also used to inform and invite participants. Students read a cover letter. If they agreed to participate, they answered questions on an 8-page questionnaire. Respondents were provided a debriefing statement and a snack equivalent to $1.50 after they completed the survey. The study procedures were reviewed and approved by the Institutional Review Board (Human Research Committee) at Colorado State University.

Survey materials (See Appendix A-C for the materials)

A cover letter (Appendix A) was prepared to explain the study and invite students to participate. The letter described the study as "a study on bicycle safety among CSU students" instead of describing as "a study on bicycle helmet use behavior and attitudes among CSU students." The mild deception was used because of a concern that students who had not worn bicycle helmets might be reluctant to participate if they knew the study was about bicycle helmet use behavior.

A debriefing statement (Appendix B) was therefore needed to disclose the actual purpose of the study and the deception. The statement was distributed after a respondent completed the survey. The statement disclosed the explanation for the deception as follows; "We did not tell you that the study was about bicycle helmet use because we wanted to invite participants with different bicycle helmet use behaviors including consistent bicycle helmet users and non-users. If we had described the study such as 'bicycle helmet use survey' in the invitation, this might confuse some students and reduce the participation of respondents who did not wear bicycle helmets."

A questionnaire (Appendix C) was developed specifically for the study. Questions included are described in detail below.

Bicycle helmet use: Bicycle use and bicycle helmet use were asked in two conditions: commuting to school (i.e., university campus) and recreation. Based on the Stages of Change model, five stages were defined to classify bicycle riders. These were:

Precontemplation stage: bicycle riders who used bicycle helmets inconsistently or did not use bicycle helmets during the past 30 days and did not have any intention to wear them consistently.

Contemplation stage: bicycle riders who wore bicycle helmets never or almost never but expressed intention to wear them consistently.

Preparation stage: bicycle riders who wore bicycle helmets sometimes or almost every time and intended to wear them consistently.

Action stage: bicycle riders who had started wearing bicycle helmets every time they rode within the past six months.

Maintenance stage: bicycle riders who wore bicycle helmets every time they rode for more than six months.

To assign individual riders to one of the five stages, three questions were used. The first question asked: "In the past 30 days, when you rode a bicycle to school, how often did you wear a helmet?" with five response options: Every time; Almost every time; Sometimes; Almost never; and Never. Bicycle riders who had worn bicycle helmets every time they rode were asked: "How long has it been since you started wearing a helmet every time you ride a bicycle to school?" to differentiate the Maintenance stage from the Action stage. Bicycle riders who never or inconsistently used bicycle helmets were asked a question to classify them in accordance with intention of consistent use: "Are you considering starting to wear a helmet every time you ride to school within the next six months?" Classification based on the three questions is shown in Table 2.

Table 2

Bicycle Helmet Use Stage Classification

	Stage				
	Precontemplation	Contemplation	Preparation	Action	Maintenance
Bicycle helmet use frequency during the past 30 days	Never Almost never Sometimes Almost every time	Never Almost never Sometimes	Almost every time	Every time	Every time
(For 'every time' users) Length of time since starting wearing a bicycle helmet every time				Less than 6 months	6 months or longer
Intention to start wearing a bicycle helmet every time within the next 6 months	No	Yes	Yes		

Another set of the same questions was used to define stages for bicycle helmet use in riding for recreation with replacing words "ride to school" with "ride for recreation."

Bicycle trip length and bicycle riding frequency: Students were asked if they rode bicycles to school. If they rode bicycles to school, trip length in minutes and miles and riding frequency per week were asked. Students were asked if they rode bicycles for recreation and, if the response was yes, how often they rode for recreation was asked. Response options for bicycle riding frequency for recreation were: one or two times a year; one or two times a semester; about once a month; almost every weekend; and, weekends and some weekdays.

Students were also asked if they were members of a cycling club.

Attitudes toward bicycle helmet use: The study used two types of attitude questions: one type included single questions with a 6-point Likert scale ranging from "Strongly disagree" to "Strongly agree" for each question; and the other included four sets of questions which used multiple semantic differential response scales.

Eight single questions with a Likert scale had been included in the adult bicycle helmet study in Fort Collins to assess attitudes of respondents toward bicycle helmet use (Kakefuda, 2006; Kakefuda et al., in press). The same questions were used in the present study. The questions were: I would be more likely to wear a helmet if my doctor told me it was important; wearing a bicycle helmet gives me peace of mind about my safety; I wear a bicycle helmet even when my friends make fun of me; if I am careful and obey rules when I ride my bicycle I do not need to wear a helmet; wearing a bicycle helmet is uncomfortable; I would probably not wear a helmet unless I had an accident and hit my head; when riding around home or short distances, I do not need to wear a bicycle helmet; and, people who are close to me benefit if I wear a bicycle helmet. Four more questions were included in this study using statements which were commonly cited as reasons why college students wore or did not wear bicycle helmets. These were: a bicycle helmet is expensive; a bicycle helmet will mess up my hair; carrying a bicycle helmet around is cumbersome; and, a bicycle helmet can prevent serious head injury if I have a bicycle accident.

The other attitude questions used a framework of semantic differential with six scales for each of four statements. Two statements asked about bicycle helmet use, and other two asked about possible bicycle helmet interventions at the university. The statements were: "Wearing a bicycle helmet when riding to school is…," "Wearing a bicycle helmet when riding for recreation is…," "Increasing bicycle helmet use among CSU students is…," and " Regulating bicycle helmet use on the CSU campus is…." The six differential scales were: effective-ineffective; good-bad; smart-foolish; comfortable-uncomfortable; necessary-unnecessary; and, beneficial-harmful, with a 6-point scale. The order of six semantic differential scales differed across the four statements.

Past bicycle helmet use experience: Two sets of questions were used regarding bicycle helmet use in the past. One set related to bicycle helmet use during elementary school, junior high school, and high school using the same question "How often did you wear a bicycle helmet during…." A 6-point Likert scales ranging from "Never" to "Always" was used. The other set related to whether a respondent lived in a place which had a law or ordinance requiring residents to wear bicycle helmets. First: "Have you ever lived in a community which has a law requiring residents to wear bicycle helmets?" If the answer was yes, the next question inquired whether the law had applied to the person when he or she had lived in the community.

Perceived norm: Based on the Theory of Reasoned Action, subjectively perceived norms of close friends, family, Fort Collins community of respondents was obtained by the question, "My close friends/family/Fort Collins think I should not/I should wear a bicycle helmet every time while riding a bicycle" with a 6-point Likert scale ranging from "I should not" to "I should."

Perception toward risk and control: To examine optimistic bias toward the risk of being involved in bicycle-related injury incidents, respondents were asked to estimate their own susceptibility to bicycle-related head injury compared to peer bicycle riders. The question was "Compared to other men/women my age, my chance of getting a bicycle-related head injury is…" with a 6-point Likert scale ranging from "Much below average" to "Much above average." Another question was used to assess respondents' estimates of injury severity if they were involved in bicycle-related head injury events. "If I were involved in a bicycle-related head injury events, the injury would be…" with a 6-point Likert scale ranging from "Not at all serious" to "Extremely serious."

Belief in personal control over bicycle-related injury incidents was assessed using two questions. First, a respondent was asked to estimate bicycle riding skill as a safe rider with reference to skills among peers. The question was "Compared to other men/women my age, my competence on the road as a safe bicycle rider is…" with a 6-point Likert scale ranging from "Much below average" to "Much above average." The second question asked a respondent about his or her bicycle riding skills.

Injury experience: Bicycle-related injury experiences of respondents and people respondents knew were asked using two sets of questions; one for injuries respondents had experienced and the other for injury experiences among people they knew. The first question asked "Have you been injured in a bicycle-related incident, which required you to visit an emergency department or to be hospitalized." If a respondent answered yes, the next question asked which parts of the body (head, face, upper body other than head, lower body) were injured. The same questions were asked about injury experiences of people whom respondents knew. An additional question, "Which treatment did you receive?" with response options of "Hospitalized" and "Emergency department visit," was asked about injury experiences among respondents.

Demographic characteristics: Respondents were asked: age in years; gender; whether domestic or international student; race, ethnicity, or nationality; and, length of time living in Fort Collins or surrounding areas.

Data analyses

Data coding

After data entry, responses on Likert scales were reverse coded, when necessary, in order to arrange all responses in the same direction with regard to bicycle helmet use behaviors. After the reverse coding, a value of '1' on a Likert scale always represented a response which was least likely to be related to frequent bicycle helmet use (e.g., negative attitudes toward bicycle helmet use) and a value of '6' represented a response which was most likely to be associated with frequent bicycle helmet use (e.g., positive attitudes toward bicycle helmet use). Blank responses were assigned to missing information. Frequency statistics of the recoded data were compared to those of the original dataset to ensure that the procedure was correctly conducted.

Creating new variables

Variables described below were created.

Bicycle use purpose: Respondents were divided into three groups based on purposes of bicycle ride. The three groups were: a group of participants who rode bicycles for both commuting and recreation; a group of participants who rode only for commuting; and a group of participants who rode only for recreation.

Bicycle helmet use stage: One of five bicycle helmet use stages were assigned to individuals using responses to three questions: bicycle helmet use in the past 30 days; the duration of time since a participant started consistent bicycle helmet use if he or she was a consistent bicycle helmet user; and an intention to wear bicycle helmet consistently in the future if a participant was not a consistent bicycle helmet user. Stages were assigned to two different bicycle use purposes, for commuting to school and for recreation.

Race/ethnicity: Most respondents were non-Hispanic white U.S. students. A race/ethnicity variable with three categories was created. The categories were; non-Hispanic white U.S. students, U.S. students other than non-Hispanic white, and international students.

Fort Collins residency: Respondents were divided into two groups based on age and the number of years living in Fort Collins and/or surrounding areas. An individual who lived in the areas since he or she was 12 years old or younger was defined as a native Fort Collins resident.

Data analytical strategy

Demographics of the study participants were compared to those of the Colorado State University (CSU) student population to examine the representativeness of the sample. As a second step of preliminary analyses, responses were compared across three different bicycle use purpose groups (riding bicycles for commuting and recreation, only for commuting, and only for recreation) to determine whether the groups shared similar attributes with regards to demographics, bicycle helmet use, and psychosocial variables. If there were differences across three groups, they were analyzed separately. Distributions were examined for interval and ordinal variables. Shapiro-Wilk test was used for assessing the normality of distribution to decide which types of statistical analyses should be used, either parametric or non-parametric statistics. When a p-value of W-statistics from the test was less than 0.0001, a non-parametric test was used.

To answer the first research question of the study, bicycle helmet use behaviors among the study participants were examined. Consistency of bicycle helmet use behaviors between two different bicycle riding purposes, commuting and recreation, was also assessed. Associations between bicycle helmet use behaviors and psychosocial and demographic variables were assessed to determine variables associated with bicycle helmet use behaviors. Exploratory factor analysis was conducted with psychosocial variables (attitudes, subjective norms, and perceptions toward risk and personal control) to reduce the number of variables to be included in analyses and to eliminate redundancy. When each variable or factor was found to be correlated with bicycle helmet use behaviors, multivariate associations between the variables and bicycle helmet use behaviors were examined with regression analysis. To understand changes in bicycle helmet use during past school years (i.e., elementary, junior high, and high school) among study participants, growth modeling (Singer & Willett, 2003) was used.

Statistical analysis

P-values of 0.05 were used to denote statistical significance in this study. Associations across all variables were examined. Bonferroni adjustment to control for multiple comparison errors was not used due to the exploratory nature of the study. SAS version 9.1 (SAS Institute Inc., Cary, NC) was used for all statistical analyses.

CHAPTER III

RESULTS

A total of 315 Colorado State University (CSU) students participated in the study. A response rate was not calculated because the number of students who did not participate was unknown. Participants were recruited at the plaza on the campus, which was an open space where many people walked by. Of 315 questionnaires returned, 10 questionnaires were excluded from the analysis because they contained one or more uncompleted pages. Therefore, responses from 305 participants were used in the study, representing 96.8% of all returned questionnaires.

Representativeness of the study participants

The total number of students enrolled at CSU during the Fall semester of 2006 was 24,670 (OBIA, 2006). Of the students, 52.0% were women; 20.0% were students aged 23 to 29 years; 9.0% were students aged 30 years or older; 12.6% were self-reported ethnic minorities excluding international students; and 3.2% were international students (OBIA, 2006). Table 3 presents percentages of women, ethnic minorities, international students, and age groups for CSU student population (n=24,670) and the study participants (n=305).

Results from chi-square test showed no significant differences between CSU student population and the study participants by gender, ethnic minority, and international student status (Table 3). However, age distributions were different between two groups (Table 3). Major differences were observed among the age groups of 18, 20, and 21. Only 5.3% of the study participants were students who were 18 years old, while 16.0% of CSU students were in that age group (Table 3). In contrast, students aged 20 and 21 years comprised of approximately 40% of the study participants, compared to 30% among CSU student population (Table 3).

Table 3

Demographics of CSU Student Population and the Study Participants

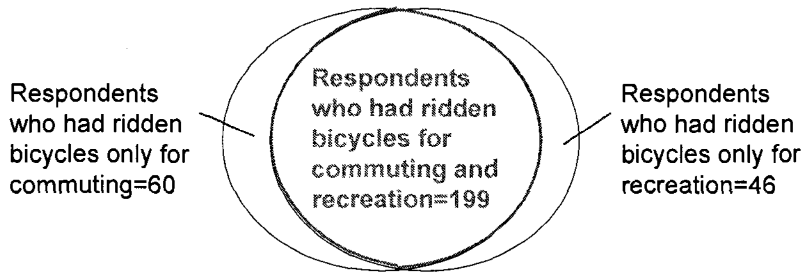
	CSU*	Respondents in the study	Chi-square statistics (*p*-value)
Gender (% female)	52.0	49.8	0.57 (0.45)
Racial/ethnic** minorities (%)	12.6	11.3	0.48 (0.49)
International students (%)	3.2	3.9	0.53 (0.47)
Age***			41.45 (<0.0001)
18 or younger	16.0	5.3	
19	15.0	17.2	
20	15.0	21.4	
21	15.0	20.5	
22	10.0	11.9	
23 - 29	20.0	15.5	
30 or older	9.0	8.2	

* OBIA, 2006
** Missing=12 (Respondents in the study)
*** Missing=2 (Respondents in the study)

Comparing three groups with different bicycle use patterns

Of 305 study participants, 199 students rode bicycles for commuting to school and for recreation (hereafter named 'Both Purpose Group'); 60 rode only for commuting ('Commuting Group'); and 46 rode only for recreation ('Recreation Group') (Figure 1).

Figure 1. Participant Groups with Different Bicycle Use Patterns



The three groups with different bicycle use patterns were compared across all study variables to determine whether the groups shared common characteristics except bicycle use and could be analyzed as a group. Non-parametric tests (Wilcoxon test or Kruskal-Wallis test) were used because all variables for the Both Purpose Group and most variables for the Commuting and Recreation Groups showed non-normal distributions.

Differences were observed across three bicycle use groups. The Both Purpose Group rode bicycles for recreation more frequently (M=3.45 on a scale ranging from 1 as being "One or two times a year" to 5 as being "Weekends and some weekdays") than the Recreation Group (M=3.00) and the mean difference was statistically significant (χ^2[1]=5.64, p=0.02). Age distributions also differed (χ^2[12]=22.88, p=0.03). A majority of the Commuting Group (73.3%) and the Recreation Group (69.6%) were students aged 19 to 21 years; while half of the Both Purpose Group (52.3%) were students of this age group and another quarter of the Both Group students (27.9%) were aged 23 years or older.

Three groups also differed in attitudes toward bicycle helmet use, perceived norms of others, perceptions toward personal control over bicycle-related injury risk, and past bicycle helmet use. Marked differences were observed in reported past bicycle helmet use in high school. The mean bicycle helmet use frequency in high school reported by the Recreation Group was 3.16 on a scale ranging from 1 to 6, where 1 as being "Not at all" and 6 as being "Every time." The mean for the Both Purpose Group was 2.70. In contrast, the mean for the Commuting Group was 1.94, and the differences were statistically significant (χ^2 [2]=9.87, p<0.01. Kruskal-Wallis test).

Results from the comparisons across three different bicycle use groups provided evidence that the groups differed in demographic variables and psychosocial variables. Therefore, later analyses used only the Both Purpose Group, a group of study participants who rode bicycles for commuting to school and for recreation. The total sample size of the group was 192, after excluding 7 respondents whose bicycle helmet use stages were missing for both of the bicycle use purposes. The sample analyzed therefore represented 63.0% of all completed surveys.

Descriptive statistics of the study respondents

Characteristics of the study participants (n=192) are shown in Table 4. One-hundred nine (57.0%) of the study participants lived in Fort Collins or the surrounding areas for less than four years. Twenty-eight (14.6%) had lived in the areas since they were 12 years old or younger and were categorized as 'native Fort Collins residents'. More than half (56.8%) of the study participants rode bicycles for commuting four days a week or more often, and 88 (45.8%) used bicycles for recreation "Almost every weekend" or more often. Five respondents (2.6%) reported that they were members of bicycle clubs.

Table 4

Characteristics of the Study Participants (n=192)

	No.	%		No.	%
Gender (Female)	98	(51.0)	Bicycle use frequency		
Age*			(for commuting to school)		
18	13	(6.8)	Less than once a week	7	(3.7)
19	30	(15.8)	1 day a week	11	(5.7)
20	33	(17.4)	2 days a week	27	(14.1)
21	38	(20.0)	3 days a week	38	(19.8)
22	25	(13.2)	4 days a week	33	(17.2)
23-29	31	(16.3)	5 days a week	49	(25.5)
30 or older	20	(10.5)	More than 5 days a week	27	(14.1)
Race/Ethnicity			Minutes of commuting*		
Non-Hispanic white	165	(85.9)	< 10 minutes	89	(46.8)
Other than Non-Hispanic white	19	(9.9)	10 min - Less than 19 min	83	(43.7)
International student	8	(4.2)	20 min or longer	18	(9.5)
Years of living in Fort Collins			Bicycle use frequency		
< 1 year	19	(9.9)	(for recreation)		
1 year - Less than 2 years	26	(13.5)	One or two times a year	10	(5.2)
2 years - Less than 3 years	31	(16.2)	One or two times a semester	30	(15.6)
3 years - Less than 4 years	33	(17.2)	About once a month	64	(33.3)
4 years - Less than 10 years	54	(28.1)	Almost every weekend	40	(20.8)
More than 10 years	29	(15.1)	Weekends and some weekdays	48	(25.0)
Native Fort Collins resident	28	(14.6)	Bicycle club membership	5	(2.6)
Having lived in a place where			Injury experience (Self)	32	(16.7)
bicycle helmet use was required**	34	(18.3)	Injury experience (Others)	100	(52.1)

*Missing=2
**Missing=6

Bicycle helmet use behaviors

Table 5 shows bicycle helmet use stages among the study participants (n=192) defined by the Stages of Change model criteria (Table 2) separately for two different bicycle use purposes. Only one student was classified as being at the Action stage which was a category for individuals who started wearing bicycle helmets every time within six months; therefore, the person was included into the Maintenance stage group.

Table 5

Stages of Change of Respondents by Bicycle Use Purpose

Stages of Change	Bicycle use purpose	
	Commuting* No. (%)	Recreation** No. (%)
Precontemplation	120 (63.8)	58 (31.4)
Contemplation	31 (16.5)	25 (13.5)
Preparation	20 (10.6)	34 (18.4)
Action***		1 (0.01)
Maintenance	17 (9.0)	67 (36.8)

* Missing=4
** Missing=7
*** Included into the Maintenance stage group

One-hundred twenty (63.8%) participants did not wear bicycle helmets at all or inconsistently when commuting to school and expressed no intention to consistently wear bicycle helmets in the future (Precontemplation stage), while 17 (9.0%) wore bicycle helmets every time (Maintenance stage). For recreation, more respondents reported consistent bicycle helmet use: 68 (36.8%) were at the Maintenance stage and 58 (31.4%) were at the Precontemplation stage.

As shown in Table 2, the Stages of Change classified individuals into the Precontemplation stage when they did not express intentions to wear bicycle helmets consistently, regardless of how often they had worn bicycle helmets in the past 30 days preceding the date of survey. When examining reported bicycle helmet use among respondents at the Precontemplation stage, a majority of those at the stage had not worn bicycle helmets in the past: 101 (84.2%) for commuting and 44 (75.9%) for recreation. Thirteen respondents (10.8%) for commuting and 7 (12.1%) for recreation reported that they had worn bicycle helmets "almost never" or "sometimes." Five participants (4.2%)

for commuting and 7 (12.1%) for recreation used bicycle helmets "almost every time"; however, they did not express an intention to consistently wear bicycle helmets in the future.

On the other hand, the stage of Contemplation included individuals who reported intentions to wear bicycle helmets every time in the future even if they had not worn bicycle helmets in the past 30 days. Nineteen (61.3%) of 31 participants at the Contemplation stage for commuting and 14 (56.0%) of 25 for recreation had not worn bicycle helmet in the past, but they expressed intentions of consistent use in the future.

Discrepancies in bicycle helmet use between two purposes

Table 6 is a cross tabulation of bicycle helmet use stages for the two purposes to assess consistency. Bicycle helmet use stages by bicycle use purpose were correlated (p<0.0001, Fisher's exact test). However, Table 6 revealed unique patterns in associations between stages of the two bicycle use purposes. Seventy-eight (43.1%) respondents reported discrepant bicycle helmet use behaviors and intentions between the purposes in the same direction: they were at higher stages for recreation than for

Table 6

A Combined Table of Stages of Change for Commuting and Recreation

		Stages of Change for Recreation purpose				Total (Commuting)
		Precontemplation	Contemplation	Preparation	Maintenance	
Stages of Change for commuting purpose	Precontemplation	58 (32.0)	7 (3.9)	14 (7.7)	35 (19.3)	114 (63.0)
	Contemplation	0 (0.0)	15 (8.3)	8 (4.4)	7 (3.9)	30 (16.6)
	Preparation	0 (0.0)	2 (1.0)	11 (6.1)	7 (3.9)	20 (11.1)
	Maintenance	0 (0.0)	0 (0.0)	0 (0.0)	17 (9.4)	17 (9.4)
	Total (Recreation)	58 (32.0)	24 (13.3)	33 (18.2)	66 (36.5)	181 (100.00)*

* Missing=11

commuting (the upper diagonal half of Table 6). Notably, 35 (19.3%) respondents were non-users or inconsistent users for commuting without the intention for consistent bicycle helmet use for the purpose (Precontemplation stage), while they wore bicycle helmets every time for recreation (Maintenance stage). Only two (1.0%) respondents showed the discrepant use in the opposite direction: being at higher stages for commuting than for recreation (the lower diagonal half of Table 6). No one wore bicycle helmets every time for commuting with non-use or inconsistent use for recreation (the bottom row of Table 6). Bicycle helmet use stages among 101 respondents (55.8%) were consistent between two bicycle use purposes (on the diagonal of Table 6). Due to the discrepancy in bicycle helmet use stages between two bicycle use purposes, bicycle helmet use behaviors were analyzed separately by purpose in the next analysis.

Variables associated with bicycle helmet use stages: Factor analysis

Correlations between bicycle helmet use and other variables are shown on Appendix D. The table also presents statistically significant correlations among variables.

Demographic characteristics and past experience variables which were associated with bicycle helmet use stages for commuting were: age; minutes of commuting; bicycle helmet use in high school; and injury experiences of people respondents knew (Appendix D). Demographics and past experience variables associated with bicycle helmet use stages for recreation were: injury experiences of people respondents knew; bicycle club membership; bicycle helmet use in junior high school; and bicycle helmet use in high school (Appendix D).

As shown in Appendix D, injury experiences of people respondents knew were associated with many other variables, while injury experiences of respondents themselves showed correlations with only a few variables: race/ethnicity (5 of 8 [62.5%] international students reported injury experiences compared to 23 of 165 [13.9%] non-Hispanic white students and 4 of 19 [21.1%] other U.S. students); commuting minutes (students with injury experiences reported longer minutes); perception toward self as a skilled bicycle rider (students with injury experiences felt they were less skilled); and, risk of involving in bicycle-related injurious incidents (students with injury experiences reported higher perceived risk).

A variable, past experience of having lived in a place where bicycle helmet use was required, was the variable which was not associated with any variables expect one: a semantic differential scale "Regulating bicycle helmets on CSU campus is [harmful - beneficial]" (Appendix D). Study participants who had lived in communities with bicycle helmet laws/ordinances inclined to 'harmful' on the scale while the mean of other participants scored the middle (2.97 vs. 3.73 on a 6-point scale, p=0.03) (Appendix D). Whether having lived a place with bicycle helmet law/ordinance did not differentiate bicycle helmet use in elementary, junior high, and high school (Appendix D). In contrast, study participants who lived in Fort Collins or surrounded areas since 12 years old or younger were more likely to wear bicycle helmets in junior high and high school compared to those who started living in the areas 13 years old or older (Appendix D).

Many attitude variables, some variables of perceptions toward personal control, and all subjective norm variables were associated with bicycle helmet use stages (Appendix D). Attitudes, perceptions toward risk and personal control, and subjective norms were also correlated with each other (Appendix D). Prior to analysis to examine associations between bicycle helmet use stages and other variables, a series of factor analyses were conducted with attitude, perception, and norm variables to reduce the number of variables to be included in statistical models.

First, each of the four sets of semantic differentials (attitudes with regard to bicycle helmet use for commuting; bicycle helmet use for recreation; increasing bicycle helmet use among CSU students; and bicycle helmet regulation on the CSU campus) was analyzed by factor analysis to examine whether six semantic differential scales (effective-ineffective; good-bad; smart-foolish; comfortable-uncomfortable; necessary-unnecessary; and, beneficial-harmful) within each set were correlated and formed a factor. Only one factor was extracted from each semantic differential set; however, a scale of 'comfortable-uncomfortable' presented a lower factor loading in every set compared to other five scales. For instance, the factor loading of the 'comfortable-uncomfortable' scale in the set of 'bicycle helmet regulation on the CSU campus' was 0.60, while factor loadings of other five items ranged from 0.83 to 0.92. For another example, the factor loading of the 'comfortable' scale in the set of 'bicycle helmet use for recreation' was 0.41; in contrast, other scales in the set showed factor loadings ranging from 0.64 to 0.82. The results suggested that the 'comfortable' scales might constitute another factor.

Factor analysis with all 24 semantic differential scales was conducted, and five factors were extracted based on eigenvalues and factor loading patterns. Eigenvalues dropped from the first factor (9.21) to the fifth (0.78) and became flat after the fifth (0.37 for the sixth factor and 0.31 for seventh). Five factors extracted based on factor loading patterns were interpretable: these were a factor consisted of the four 'comfortable-uncomfortable' scales extracted from four semantic differential sets and other four factors representing each of 'bicycle helmet use for commuting,' 'bicycle helmet use for recreation,' 'increasing bicycle helmet use among CSU students,' and 'bicycle helmet regulation on the CSU campus' with five semantic differential scales for each factor.

Other 12 attitude questions than semantic differentials, three subjective norm questions, and four questions regarding perceptions toward risk and personal control were analyzed with factor analysis. Five factors were extracted from the 19 items. The factors were as follows.

1. A factor 'Need of bicycle helmet use' included four attitude questions.
   - When riding around home or short distances, I do not need to wear a bicycle helmet.
   - I would probably not wear a helmet unless I had an accident and hit my head.
   - I wear a bicycle helmet even when my friends make fun of me.
   - If I am careful and obey rules when I ride my bicycle I do not need to wear a helmet.
2. 'Emotional importance of bicycle helmet use' included three attitude questions and three subjective norm questions.
   - A bicycle helmet can prevent serious head injury if I have a bicycle accident.
   - Wearing a bicycle helmet gives me peace of mind about my safety.
   - People who are close to me benefit if I wear a bicycle helmet.
   - Subjective norm of family (perception of a respondent whether his or her family think he or she should wear a bicycle helmet).
   - Subjective norm of friends (perception of a respondent whether his or her friends think he or she should wear a bicycle helmet).
   - Subjective norm of Fort Collins (perception of a respondent whether the atmosphere of Fort Collins encourages him or her to wear a bicycle helmet).
3. 'Inconvenience of bicycle helmet use' included four attitude questions.

- A bicycle helmet is expensive.

- A bicycle helmet will mess up my hair.

- Carrying a bicycle helmet around is cumbersome.

- Wearing a bicycle helmet is uncomfortable.

4. 'Perceptions toward bicycle-related injury' included one attitude question and two risk perception questions.

- I would be more likely to wear a helmet if my doctor told me it was important.

- Compared to other men/women my age, my chance of getting a bicycle-related head injury is much below/above average.

- If I were involved in a bicycle-related head injury event, the injury would be not at all serious/extremely serious.

5. 'Perceptions toward control on the road' included two questions.

- Compared to other men/women my age, my competence on the road as a safe bicycle rider is much below/above average.

- Compared to other men/women my age, my competence on the road as a skilled bicycle rider is much below/above average.

In summary, five factors were extracted from semantic differential scales and five other factors were created from attitudes, subjective norms, and perceptions toward risk and personal control. The ten factors were correlated with bicycle helmet use stages for commuting and recreation with two exceptions: a factor 'perceptions toward personal control on the road' was not associated with bicycle helmet use stages for commuting (p=0.05, Kruskal-Wallis test); and another factor 'bicycle helmet regulation on the CSU campus' was not associated with bicycle helmet use stages for recreation (p=0.42).

Variables associated with bicycle helmet use stages: Regression analysis

Bicycle helmet use stage was an ordinal variable, not an interval variable which should hold an assumption that intervals between different levels in a variable were the same. For instance, to consider bicycle helmet use stage as an interval variable, the distance between the Precontemplation stage and the Contemplation stage should be the same as the distance between the Action stage and the Maintenance stage. The study did not assume this to be true for the stage variable. Due to the nature of the bicycle helmet use stage variable, logistic regression analysis was used to examine associations between bicycle helmet use stages and other variables.

Table 7 and 8 present results from multivariate logistic regression analyses for models of two different bicycle use purposes. Variables and factors associated with bicycle helmet use stages in univariate analyses were included in multivariate models. The variables and factors were as follows.

<u>Bicycle helmet use stage for commuting (Table 7):</u> gender; age; minutes of commuting; bicycle helmet use in high school; injury experiences of people respondents knew; and, factors of 'bicycle helmet use for commuting'; 'bicycle helmet use for recreation'; 'increasing bicycle helmet use among CSU students'; 'bicycle helmet regulation on the CSU campus'; 'feeling comfortable with bicycle helmet use and bicycle helmet promotion efforts at CSU'; 'need of bicycle helmet use'; 'emotional importance of bicycle helmet use'; 'inconvenience of bicycle helmet use'; and, 'perceptions toward bicycle-related injury.'

<u>Bicycle helmet use stage for recreation (Table 8):</u> bicycle helmet use in junior high school; bicycle helmet use in high school; injury experiences of people respondents

Table 7

*Multivariate Proportional Odds Regression Model for Bicycle Helmet Use for Commuting with Variables Associated with Use in Univariate Analysis**

Variable	Reference	Odds ratio	95%CI
Gender	Female	**5.28**	**1.98-14.05**
Age	Older	1.02	0.94-1.11
Minutes of commuting	Longer	**1.13**	**1.05-1.21**
Helmet use in high school	Frequent	1.12	0.87-1.44
Injury experiences of others	Yes	1.16	0.45-2.97
Helmet use for commuting	Positive	1.24	0.55-2.81
Helmet use for recreation	Positive	0.60	0.24-1.51
Increasing helmet use among CSU students	Positive	**3.48**	**1.66-7.30**
Helmet regulation on CSU campus	Positive	0.74	0.51-1.06
Comfortable with helmet use and promotion efforts	Comfortable	0.91	0.60-1.38
Need of bicycle helmet use	High need	1.65	0.98-2.78
Emotional importance of helmet use	Important	**4.04**	**1.73-9.40**
Inconvenience of bicycle helmet use	Not inconvenient	**1.78**	**1.09-2.90**
Perceptions toward bicycle-related injury	High risk	1.37	0.72-2.62

*n=149

Table 8

Multivariate Proportional Odds Regression Model for Bicycle Helmet Use for Recreation with Variables Associated with Use in Univariate Analysis

Variable	Reference	Odds ratio	95%CI
Helmet use in junior high school	Frequent	0.87	0.66-1.14
Helmet use in high school	Frequent	**1.48**	**1.08-2.03**
Injury experiences of others	Yes	1.31	0.59-2.89
Helmet use for commuting	Positive	**0.27**	**0.13-0.56**
Helmet use for recreation	Positive	**12.32**	**5.02-30.21**
Increasing helmet use among CSU students	Positive	0.88	0.51-1.52
Comfortable with helmet use and promotion efforts	Comfortable	1.34	0.93-2.01
Need of bicycle helmet use	High need	1.19	0.74-1.90
Emotional importance of helmet use	Important	**2.56**	**1.24-5.29**
Inconvenience of bicycle helmet use	Not inconvenient	**1.68**	**1.09-2.59**
Perceptions toward bicycle-related injury	High risk	0.82	0.46-1.18
Perceptions toward control on the road	Low control	**0.59**	**0.38-0.91**

*n=145

Odds ratio presents odds of being at (a) lower stage(s) compared to the reference group or reference scale point.

knew; and, factors of 'bicycle helmet use for commuting'; 'bicycle helmet use for recreation'; 'increasing bicycle helmet use among CSU students'; 'feeling comfortable with bicycle helmet use and bicycle helmet promotion efforts at CSU'; 'need of bicycle helmet use'; 'emotional importance of bicycle helmet use'; 'inconvenience of bicycle helmet use'; 'perceptions toward bicycle-related injury'; and, 'perceptions toward personal control on the road.' Bicycle club membership was associated with the stages but not included in the model because there were only five bicycle club members and also because there was no variability among the five respondents in bicycle helmet use stages: they were all at the Maintenance stage for recreation.

Due to the listwise deletion of observations with missing, the numbers of respondents included in the analyses were 149 for commuting and 145 for recreation (the total number of study participants =192). Participant groups with and without missing values did not differ in all variables and factors according to the results of non-parametric tests (chi-square test or Kruskal-Wallis test), indicating that deletion of observations with missing did not have a large impact on results except decreasing a statistical power by reducing sample size.

Models converged and goodness-of-fit statistics were significant: chi-square statistics of likelihood ratios were 124.63 (p<0.0001) for the commuting model and 133.04 (p<0.0001) for the recreation model. Score tests for the proportional odds assumption provided non-significant values for the commuting model ($\chi^2[28]=39.50$, p=0.07) and for the recreation model ($\chi^2[24]=33.70$, p=0.09), supporting that the proportional odds assumption held for the data. With the assumption, odds ratios obtained from multivariate logistic regression (Table 7 and 8) can be applied to any comparisons of stages as cumulative odds. For example, when a student is male, the odds of being at the Precontemplation stage versus being at higher three stages is 5.28 times higher than a female after controlling for effects of other variables (Table 7). The interpretation of the odds ratio for gender is also applicable to two other comparisons: being male increases odds of being at a combined category of the Precontemplation and Contemplation stages versus being at the higher combined category of the Preparation and Maintenance stages; and also, increases odds of being at a combined three lower stages versus being at the highest Maintenance stage.

Five variables were significant in the commuting model (Table 7). These were: gender; minutes of commuting; and factors of 'increasing bicycle helmet use among CSU students'; 'emotional importance of bicycle helmet use'; and, 'inconvenience of bicycle helmet use.' Being male, shorter minutes of commuting, having negative attitudes toward increasing bicycle helmet use among CSU students, feeling less emotional importance in bicycle helmet use, and feeling more inconvenience of bicycle helmet use were associated with the risks of being at a lower stage (or lower combined stages) concerning bicycle helmet use for commuting to school (Table 7).

Six variables were correlated with bicycle helmet use stages for recreation (Table 8). The variables were: past bicycle helmet use in high school; and factors of 'bicycle helmet use for commuting'; 'bicycle helmet use for recreation'; 'emotional importance of bicycle helmet use'; 'inconvenience of bicycle helmet use'; and, 'perceptions toward control on the road.' Less frequent bicycle helmet use in high school, negative attitudes toward bicycle helmet use for recreation, feeling less emotional importance in bicycle helmet use, and feeling more inconvenience of bicycle helmet use were associated with being at lower stages of bicycle helmet use for recreation (Table 8). In contrast, negative attitudes toward bicycle helmet use for commuting were associated with higher bicycle helmet stages for recreation. In addition, perceiving one's competence as a safer and/or more skilled bicycle rider compared to peer bicycle riders was associated with higher bicycle helmet stages for recreation. In other words, respondents who considered themselves as safer and/or more skilled bicycle riders were likely to wear bicycle helmets more often for recreation than those who did not think they were competent on the road.

Pseudo R-squared was calculated for the two models. The value was 0.57 for the commuting model and 0.60 for the recreation model. The pseudo R-squared is an approximation to R-squared available from ordinary least square method and illustrates the strength of association between outcome variable and other variables in a model.

Table 9 presents models for commuting and for recreation which included the same set of variables in each model for the purpose of comparison. Patterns of associations were consistent with the previous models (Table 7 and 8) and odds ratios were similar regardless of whether only significant variables were included (Table 7 and 8) or other variables were included (Table 9). In summary, only two factors, 'emotional importance of bicycle helmet use' and 'inconvenience of bicycle helmet use,' were consistently associated with bicycle helmet use for both purposes.

Table 9

Multivariate Proportional Odds Regression Models for Bicycle Helmet Use for Communing and for Recreation with the Same Set of variables

Variable	Reference	Odds ratio	95%CI	Odds ratio	95%CI
		Commuting		Recreation	
Gender	Female	**6.43**	**2.27-18.21**	1.10	0.47-2.57
Age	Older	1.03	0.95-1.13	1.01	0.93-1.11
Minutes of commuting	Longer	**1.13**	**1.04-1.21**	1.04	0.97-1.10
Helmet use in junior high school	Frequent	0.98	0.70-1.37	0.91	0.68-1.23
Helmet use in high school	Frequent	1.13	0.79-1.61	**1.46**	**1.06-2.01**
Injury experiences of others	Yes	1.15	0.44-2.99	1.35	0.60-3.03
Helmet use for commuting	Positive	1.13	0.48-2.63	**0.27**	**0.13-0.58**
Helmet use for recreation	Positive	0.57	0.22-1.45	**11.92**	**4.70-30.24**
Increasing helmet use among CSU students	Positive	**3.77**	**1.77-8.04**	0.97	0.54-1.73
Helmet regulation on CSU campus	Positive	0.77	0.53-1.11	0.90	0.64-1.28
Comfortable with helmet use and promotion efforts	Comfortable	0.90	0.59-1.37	1.35	0.91-2.01
Need of bicycle helmet use	High need	1.68	1.00-2.83	1.16	0.72-1.89
Emotional importance of helmet use	Important	**3.61**	**1.54-8.48**	**2.51**	**1.17-5.38**
Inconvenience of bicycle helmet use	Not inconvenient	**1.88**	**1.15-3.08**	**1.67**	**1.07-2.60**
Perceptions toward bicycle-related injury	High risk	0.68	0.39-1.20	**0.59**	**0.38-0.93**
Perceptions toward control on the road	Low control	1.27	0.65-2.46	0.87	0.48-1.59

Odds ratio presents odds of being at (a) lower stage(s) compared to the reference group or reference scale point.

Comparing groups with different bicycle helmet use stage combinations

Logistic regression analysis conducted in the last section revealed that different variables were associated with bicycle helmet use stages for two different bicycle use purposes, commuting and recreation. However, results obtained in the analyses did not provide information with regard to the observed consistency and discrepancy in bicycle helmet use stages between the two bicycle uses, which were shown in Table 6. This section describes characteristics of groups who presented consistent or discrepant bicycle helmet use stages for commuting and for recreation.

The analyses used 145 participants who were at the Precontemplation stage and/or the Maintenance stage for commuting and/or for recreation. Five groups were created from the 145 participants. The groups were:

Group 1 (n=58): Participants who were at the Precontemplation stage for commuting and for recreation. They never or inconsistently wore bicycle helmets for both purposes and expressed no intention to consistently wear bicycle helmets in the future.

Group 2 (n=21): Participants who were at the Precontemplation stage for commuting and those who were at Contemplation or Preparation stages for recreation. They never or inconsistently wear bicycle helmets for commuting with no intention for consistent use for the purpose; however, they expressed intentions to consistently use bicycle helmets for recreation.

Group 3 (n=35): Participants who were at the Precontemplation stage for commuting and were at the Maintenance stage for recreation. They never or inconsistently wore bicycle helmets for commuting and expressed no intention to consistently use; however, they always wore bicycle helmets for recreation.

Group 4 (n=14): Participants who were at either Contemplation or Preparation stages for commuting and were at the Maintenance stage for recreation. They inconsistently used bicycle helmets for commuting but expressed intentions to consistently use, and they always wore bicycle helmets for recreation.

Group 5 (n=17): Participants who were at the Maintenance stage for commuting and for recreation. They always wore bicycle helmets for both purposes.

Descriptive statistics and results of statistical tests are shown in Table 10 and Figures 2 to 11. Psychosocial variables were grouped by factors in the figures.

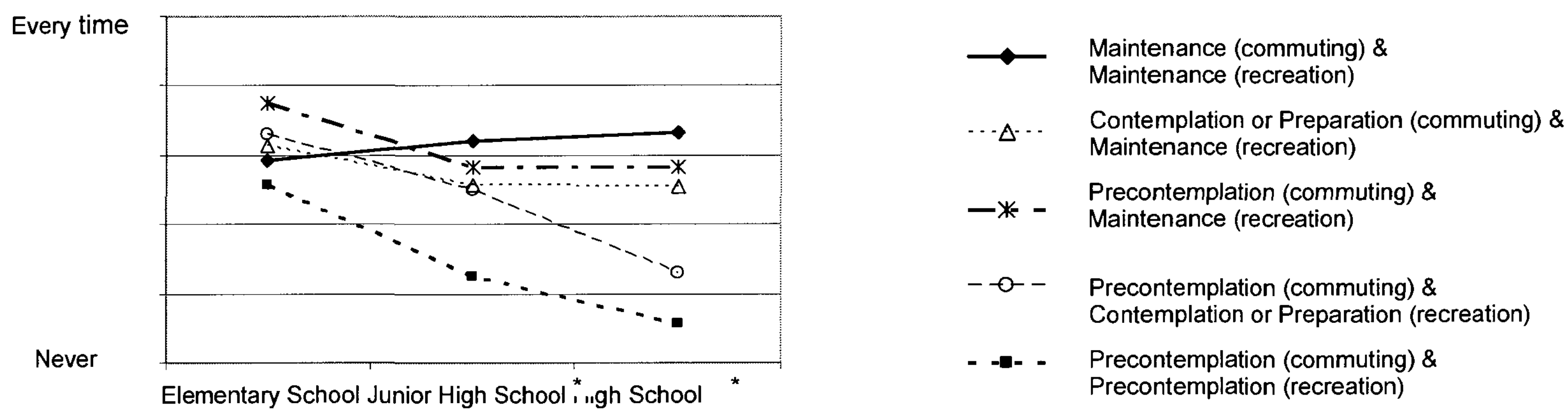
Table 10.

Characteristics of Five Different Bicycle Helmet Use Stage Groups

Helmet use stage for commuting	Precontemplation	Precontemplation	Precontemplation	Contemplation or Preparation	Maintenance	Statistics* (p-value)
Helmet use stage for recreation	Precontemplation	Contemplation or Preparation	Maintenance	Maintenance	Maintenance	
	(n=58)	(n=21)	(n=35)	(n=14)	(n=17)	
Categorical variables	No. (% in each bicycle use stage group)					
Gender (female)**	31 (53.45)	5 (23.81)	13 (37.14)	9 (64.29)	9 (52.94)	8.77 (p=0.067)
Race/ethnicity						
Non-Hispanic white	50 (86.21)	18 (85.71)	29 (82.86)	13 (92.86)	15 (88.24)	p=0.98
Other than Non-Hispanic white	5 (8.62)	3 (14.29)	4 (11.43)	1 (7.14)	2 (11.76)	
International student	3 (5.17)	0 (0.00)	2 (5.71)	0 (0.00)	0 (0.00)	
Native Fort Collins resident**	7 (12.07)	3 (14.29)	5 (14.29)	2 (14.29)	4 (23.53)	p=0.81
Bicycle club member**	0 (0.00)	0 (0.00)	3 (8.57)	2 (14.29)	0 (0.00)	**p=0.02**
Having lived in a place with law**	10 (18.18)	2 (9.52)	7 (4.93)	4 (28.57)	3 (17.65)	p=0.71
Injury experiences (Self)**	9 (15.52)	3 (14.29)	6 (17.14)	2 (14.29)	6 (35.29)	p=0.46
Injury experiences (Others)**	20 (34.48)	9 (42.86)	22 (62.86)	9 (64.29)	14 (82.35)	**16.53 (p<0.01)**
Interval or ordinal variables	Mean (SD)					
Mean age	22.79 (5.37)	22.45 (3.62)	21.63 (3.81)	21.93 (5.01)	25.71 (7.60)	7.73 (p=0.10)
Mean years of living in Fort Collins	5.10 (5.63)	4.87 (5.11)	4.69 (5.32)	5.01 (6.70)	7.52 (8.17)	1.78 (p=0.78)
Mean frequency of commuting***	4.41(1.76)	5.33 (1.28)	5.29 (1.45)	4.64 (1.34)	4.41 (1.66)	9.17 (p=0.06)
Mean minutes of commuting	10.12 (6.01)	7.95 (4.26)	8.34 (3.95)	11.57 (4.85)	18.63 (15.28)	**12.69 (p=0.01)**
Mean frequency of recreation****	3.29 (1.11)	3.33 (1.35)	3.60 (1.22)	4.07 (1.00)	3.71 (1.21)	6.15 (p=0.19)

* Chi-square test, Fisher's exact test, or Kruskal-Wallis test were used.
** Dichotomous variables. Counterpart categories are not shown.
*** A scale ranged between 1 (less than once a week) and 7 (more than 5 days a week)
**** A scale ranged between 1 (one or two times a year) and 5 (weekends and some weekdays)

Figure 2. Average Bicycle Helmet Use in the Past (Elementary School, Junior High School, and High School) among Five Different Bicycle Helmet Use Stage Groups



* Average bicycle helmet use in junior high school and high school were different across groups (*ps*<0.001)

Figure 3. Average Semantic Differential Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Bicycle Helmet Use for Commuting'

A statement:

"Wearing a bicycle helmet when riding to school is..."

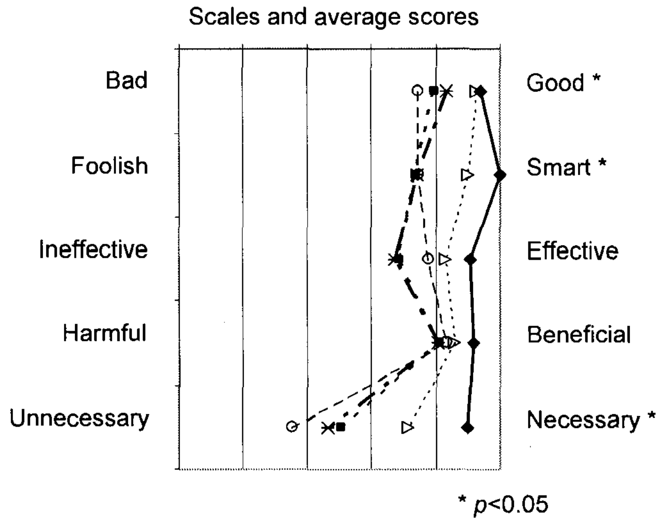
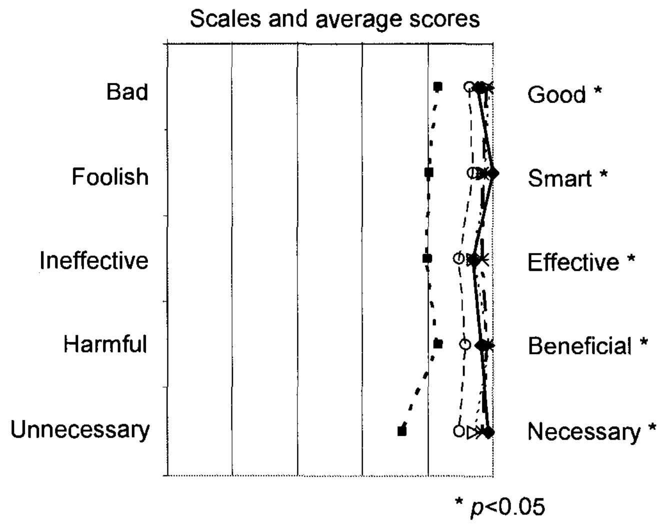


Figure 4. Average Semantic Differential Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Bicycle Helmet Use for Recreation'

A statement:

"Wearing a bicycle helmet when riding for recreation is..."



Maintenance (commuting) & Maintenance (recreation)
Contemplation or Preparation (commuting) & Maintenance (recreation)
Precontemplation (commuting) & Maintenance (recreation)
Precontemplation (commuting) & Contemplation or Preparation (recreation)
Precontemplation (commuting) & Precontemplation (recreation)

Figure 5. Average Semantic Differential Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Increasing Bicycle Helmet Use among CSU Students'

A statement:

"Increasing bicycle helmet use among CSU students is…"

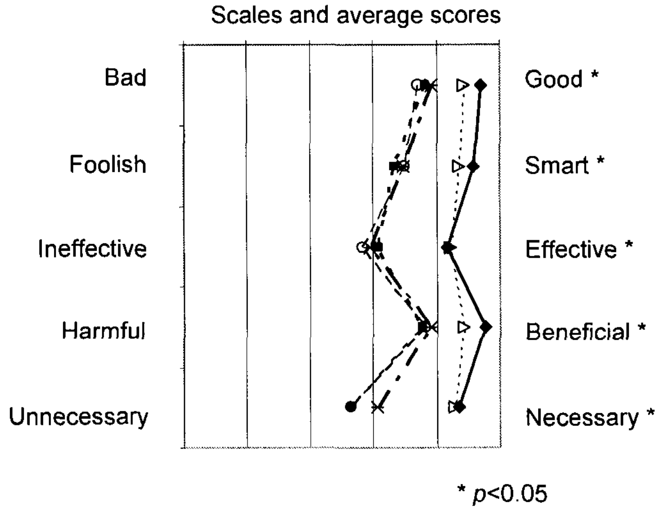
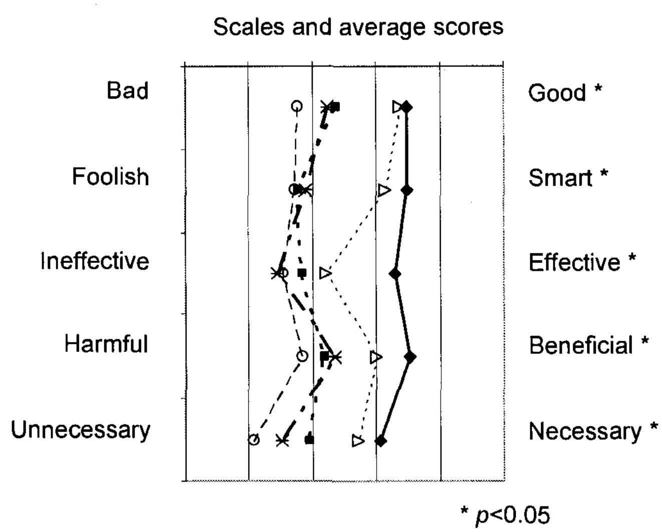


Figure 6. Average Semantic Differential Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Bicycle Helmet Regulation on CSU Campus'

A statement:

"Regulating bicycle helmet use on the CSU campus is…"



Maintenance (commuting) & Maintenance (recreation)
Contemplation or Preparation (commuting) & Maintenance (recreation)
Precontemplation (commuting) & Maintenance (recreation)
Precontemplation (commuting) & Contemplation or Preparation (recreation)
Precontemplation (commuting) & Precontemplation (recreation)

Figure 7. Average Semantic Differential Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Feeling Comfortable with Bicycle Helmet Use and Bicycle Helmet Promotion Efforts'

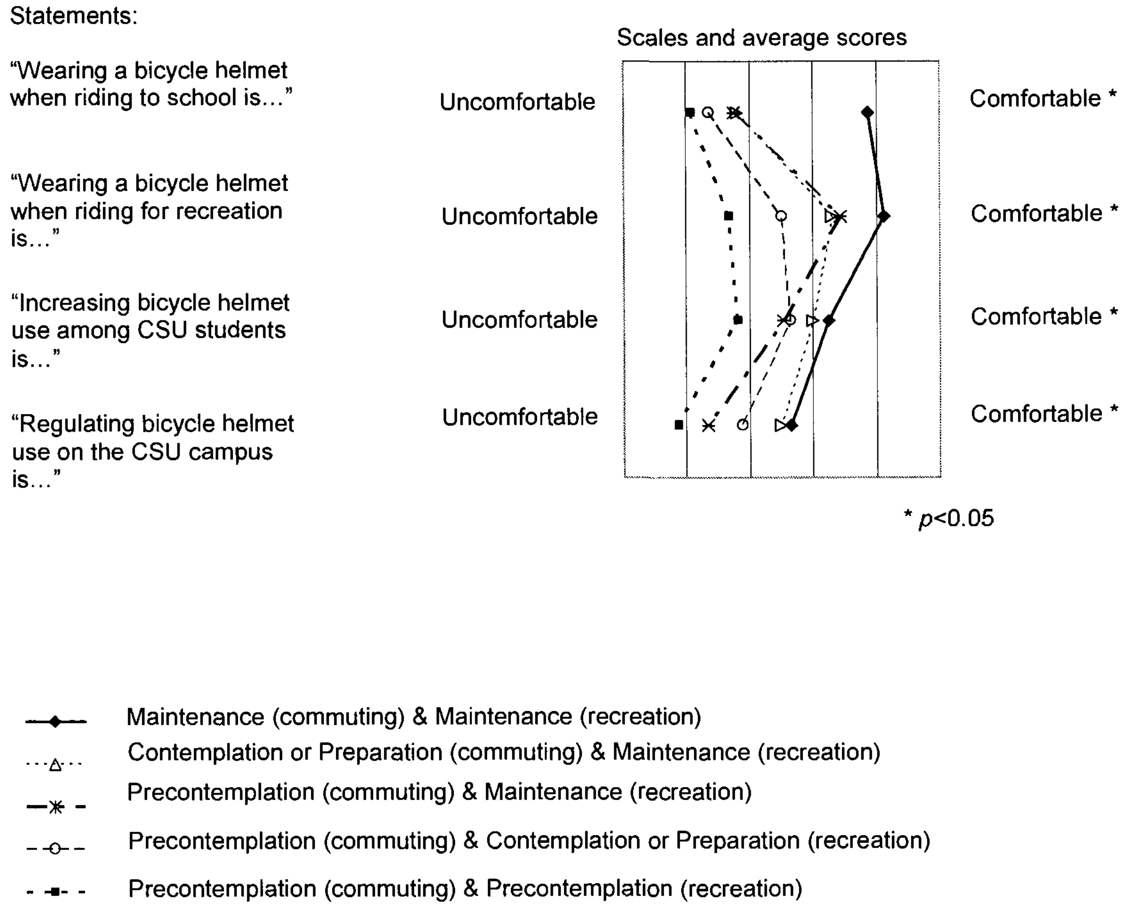


Figure 8. Average Attitude Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Need of Bicycle Helmet Use'

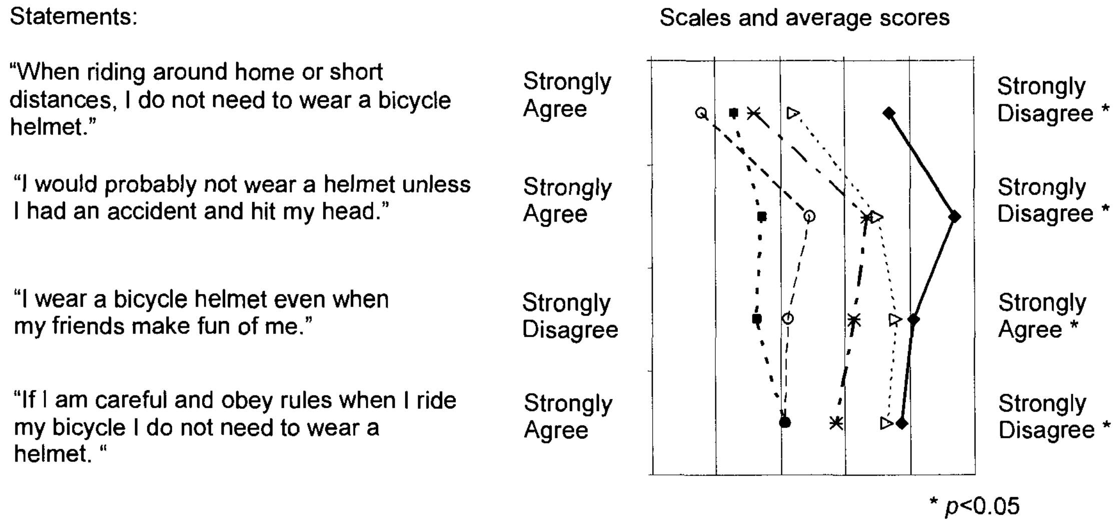


Figure 9. Average Attitude and Norm Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Emotional Importance of Bicycle Helmet Use'

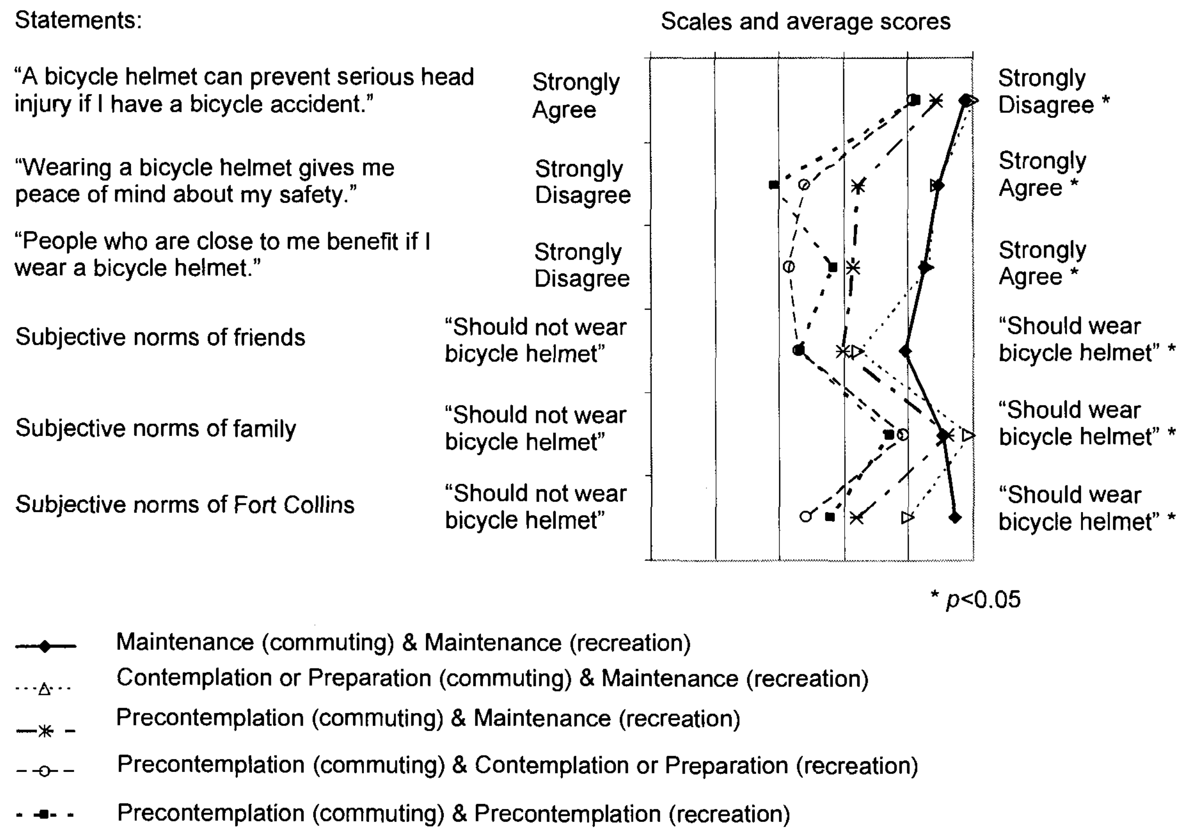


Figure 10. Average Attitude Scores among Five Different Bicycle Helmet Use Stage Groups: Factor 'Inconvenience of Bicycle Helmet Use'

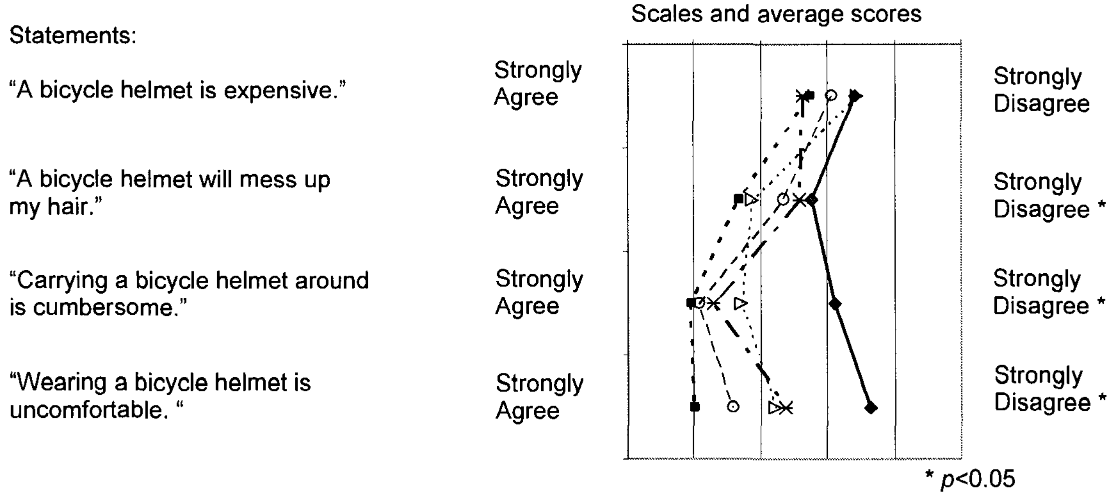
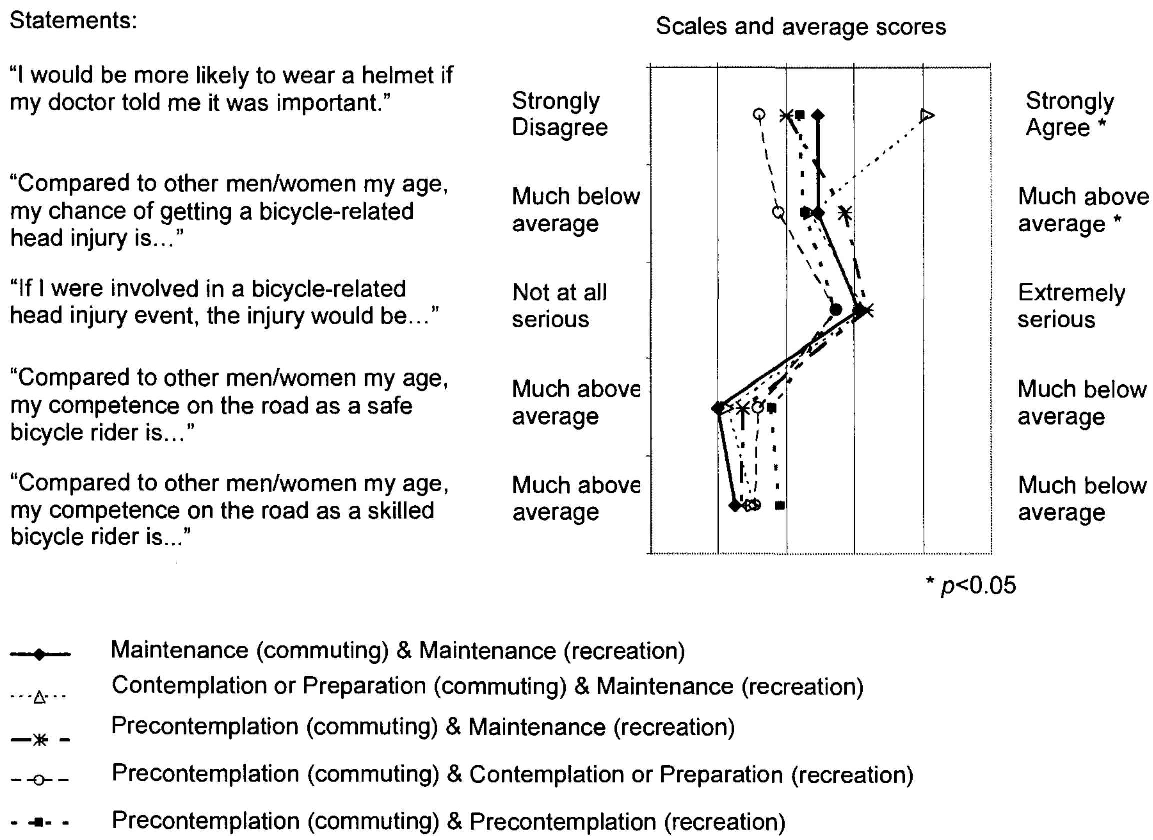


Figure 11. Average Scores among Five Different Bicycle Helmet Use Stage Groups: Factors 'Perceptions toward Bicycle-related Injury and Perceptions toward Control'



The five groups differed in percentages of participants who were members of bicycle clubs, who knew other people experiencing bicycle-related injuries, and average minutes of commuting (Table 10). All bicycle club members were at the Maintenance stage for recreation but did not always wear bicycle helmets for commuting (Table 10).

Knowing people who had bicycle-related injuries was reported by 14 of 17 students (82.4%) who wore bicycle helmets every time for commuting and for recreation; in contrast, among those who never or inconsistently use bicycle helmets with no intention to consistently use, 20 of 58 (34.5%) knew people injured in bicycle-related incidents (Table 10). Personal injury experiences were not associated with the stage group membership (Table 10). However, all six participants who were at the Maintenance stage for both bicycle use purposes and who experienced bicycle-related injuries also knew people who had bicycle-related injuries.

Average minutes of commuting were longer among students who wore bicycle helmets for both purposes (18.6min) compared to other groups (ranging from 8.0 to 11.6min). However, the standard deviation of the former group was wider (15.28) compared to other groups (ranging from 3.95 to 6.01). The actual minutes of the longest mean commuting group ranged from 4 to 60min. When closely examined, this group included two students whose commuting munites were the longest (60min and 45min) of all participants. When the two individuals were excluded, the average minutes of commuting minutes for the group decreased to 13.8 (SD=7.69), and the difference across groups became smaller (χ^2 [4]=9.54, p=0.05. Kruskal-Wallis test). Average bicycle use for commuting and for recreation did not differ across groups (Table 10).

Figure 2 illustrates trajectories of average bicycle helmet use in the past (elementary school, junior high school, and high school). The scale used six points ranging from "having not worn a bicycle helmet at all" to "having worn a bicycle helmet every time." Average past bicycle helmet use among three groups of participants who currently wore bicycle helmets every time for recreation (but their current bicycle helmet use for commuting varied) were relatively stable across time. In contrast, other two groups who currently did not use or inconsistently used bicycle helmets for commuting and for recreation presented bicycle helmet use trajectories which decreased over time. Average bicycle helmet use in elementary school were not different across five groups (χ^2[4]=6.49, p=0.17. Kruskal-Wallis test); however, use in junior high school and high school differed (χ^2[4]=20.03, p<0.001, χ^2[4]=39.76, p<0.0001, respectively).

Semantic differentials revealed differences and similarities across groups with regard to bicycle helmet use behaviors for commuting and for recreation (Figures 3 and 4). There were also differences and similarities across multiple dimensions of attitudes toward the behaviors. As shown in Figure 4, participants consistently expressed positive attitudes (evaluative and emotional attitudes) toward bicycle helmet use for recreation. Even the group who did not wear bicycle helmet for recreation as well as for commuting, those who were at the Precontemplation stage for both purposes, scored high on all bipolar scales (Figure 4). In contrast, attitudes toward bicycle helmet use for commuting varied across five groups, and response patterns among the groups differed across five scales (Figure 3). Notable differences are evident on the scale 'unnecessary-necessary.' Three groups which were at the Precontemplation stage for commuting were located around the middle or toward 'unnecessary' on the scale (Figure 3). Another group who expressed an intention of consistent bicycle helmet use for commuting also diverged on the ‘unnecessary-necessary’ scale from the group who were at the Maintenance stage for both purposes, although the two groups scored closer on the scales of ‘bad-good’ and ‘foolish-smart’ (Figure 3).

Wearing bicycle helmets every time for commuting or even merely having an intention of consistent use for commuting might lead individuals to have positive attitudes toward the importance of increasing bicycle helmet use among CSU students (Figure 5). Two groups, one at the Maintenance stage for commuting and for recreation and the other at the Contemplation/Preparation stage for commuting and the Maintenance stage for recreation, scored similarly on the five semantic differential scales, while scores of the other three groups were lower than the former two groups (Figure 5).

Semantic differentials with regard to bicycle helmet regulation on the CSU campus (Figure 6) demonstrate differences compared to the three other semantic differentials. Those who were at the Precontemplation stage for commuting expressed negative attitudes on all semantic differential scales (Figure 6). Students who were at the Maintenance stage for commuting and for recreation expressed more positive attitudes toward a regulation; however, their scores were still closer to the middle of scales (Figure 6).

The ‘uncomfortable-comfortable’ scales extracted from four sets of semantic differentials through factor analysis showed interesting patterns (Figure 7). Only the group who were at the Maintenance stage for commuting felt comfortable with bicycle helmet use for commuting and for recreation. The group who wore bicycle helmets inconsistently for commuting expressed uncomfortable feelings in spite of their intentions to wear bicycle helmets (Figure 7). With regard to feeling comfortable with bicycle helmet use for recreation, participants at the Maintenance stage for the purpose felt more comfortable with bicycle helmet use than others at lower stages (Figure 7).

Bicycle helmet promotion efforts including a regulation on the CSU campus were not perceived to be comfortable by those at the Precontemplation stage for commuting (Figure 7). Even the group of participants who wore bicycle helmets every time for commuting were toward the middle of the attitude scales with regard to the importance of increasing bicycle helmet use among CSU students and bicycle helmet regulation on the CSU campus (Figure 7).

Figures 8 and 9 illustrate differences across five groups in relation to the need to use bicycle helmets, emotional importance of use, and subjective norms of others. As shown in the top line of Figure 9, study participants believed bicycle helmets would be effective in preventing serious head injuries. Despite this belief, participants reported it was not necessary to wear bicycle helmets for short distance except the group who always wore bicycle helmets for commuting (Figure 8). Even participants who wore bicycle helmets inconsistently for commuting with an intention of consistent use scored lower on the 'short distance' compared to the always-use group (Figure 8). The discrepancy between the two groups was observed on the next scale with regard to perception toward a bicycle helmet as a precautionary measure (Figure 8). However, the two groups scored closely on scales of 'emotional importance of bicycle helmet use' (three top scales on Figure 9), and subjective norms of family (Figure 9). The inconsistent helmet users for commuting felt that bicycle helmet use was important, but did not feel the need. Subjective norms of family were higher for all groups, while norms of friends and Fort Collins varied across groups (Figure 9).

Levels of inconvenience and discomfort caused by bicycle helmet use differed between the group who wore bicycle helmet every time for commuting and for recreation and the other four groups (Figure 10). Interestingly, participants who used bicycle helmets every time for commuting and for recreation did not 'strongly disagree' with the statement "A bicycle helmet will mess up my hair." They thought that the statement was true to some degree, but yet they always wore bicycle helmets.

Among three variables of perceptions toward bicycle-related injuries (Figure 11), responses to the 'recommendation from primary physician' item showed unique patterns: the average score of the group who were at the Maintenance stage for recreation and at the Contemplation/Preparation stages for commuting was 1.5 point or higher than other groups (Figure 11). Half of the group, seven of 14 participants, answered "strongly agree" to the statement.

Past helmet use behaviors

Bicycle helmet use in the past presented different trajectories across five bicycle helmet stage groups (Figure 2). In univariate analyses, past bicycle helmet use in high school was associated with current bicycle helmet use stages for commuting and recreation, and past use in junior high school was associated with bicycle helmet use stages for recreation (Appendix D). After controlling for other variables, past use in high school was correlated with bicycle helmet use stages for recreation (Table 8). Past use in elementary school was not associated with current bicycle helmet use stages; however, bicycle helmet use in elementary school was correlated with use in junior high school (0.67, $p<0.0001$. Kendall tau correlation. Appendix D) and with use in high school (0.41, $p<0.0001$. Appendix D). Bicycle helmet use in junior high school was correlated with use in high school (0.64, $p<0.0001$. Appendix D).

Growth modeling was used to examine differences in trajectories of past bicycle helmet use across individuals and to identify variables associated with the differences. Variables included in the analysis were demographic characteristics and variables which might affect bicycle helmet use in the past: gender; age; having lived in a place where bicycle helmet use was required; subjective norms of family regarding bicycle helmet use; and, whether or not respondents were native Fort Collins residents. Current bicycle helmet use was not included in the analysis because the study did not ask participants about overall current bicycle helmet use.

Study participants (n=174) who used bicycles for commuting and for recreation, and who did not have missing data on past bicycle helmet use were included in the analyses. Bicycle helmet use during childhood and adolescent might differ by age of respondents. To eliminate a cohort effect, average past bicycle helmet use in elementary, junior high, and high school were calculated by age group. Average bicycle helmet use was consistently low over time among students aged 25 years and older. All participants younger than 25 showed average bicycle helmet use greater than 'half of the time' they rode bicycles in elementary school and use tended to decline across time. Therefore, the later analysis included only respondents who were 24 years or younger (n=142).

First, the average initial status (i.e., the average bicycle helmet use in elementary school), the rate of change across time, and the correlation between the two were calculated. The average initial status was 4.61 (SD=1.83) on a scale ranging from 1 (having never worn a bicycle helmet) to 6 (having worn a bicycle helmet every time), and the average rate of change was -0.88 (SD=1.03). The initial status and rate of change were correlated (r=-0.51, p<0.0001). The results indicated that respondents who were aged 24 years or younger had worn bicycle helmets more than half of the time they rode bicycles when they were elementary school students; however, use declined as they became older. The negative correlation between initial status and rate of change suggests that rates of decline were smaller among respondents whose bicycle helmet use in elementary school were lower compared to those who wore bicycle helmet more often in elementary school.

Table 11 presents results of growth modeling. For the analysis, variables were all centered with means being 0. The unconditional mean model was the overall average of bicycle helmet use among the study participants across three time points. The unconditional growth model, which included time as a variable, provided evidence of significant variability across individual trajectories in initial status ("Level 2 variance component for initial status." δ_0^2=2.61, p<0.0001) and in rate of change ("Level 2 variance component for rate of change." δ_1^2=0.58, p<0.0001). The results indicated that further analysis was warranted.

A series of analyses revealed that age was associated with initial status and rate of change: one unit increase in age was related to a decrease in initial status by -0.35; and one unit increase in age increased the rate of change in bicycle helmet use (the steepness of the slope) across time by 0.13 (Table 11). The results indicate that older respondents wore bicycle helmets less often in elementary school compared to younger respondents; however, bicycle helmet use among older respondents declined less rapidly over time compared to younger respondents. In addition, subjective norms of family and being native Fort Collins residents were associated with the rate of change over time (Table 11).

One unit increase in the family norm scale was associated with an increase in the rate of change by 0.25, and being native Fort Collins residents increased the rate of change by 0.50, suggesting that positive family norms toward bicycle helmet use and living in Fort Collins area since childhood decelerated the decline in bicycle helmet use over time. Gender and having lived in a place with a bicycle helmet law or ordinance were not associated with initial status or rate of change. To evaluate the utility of models with multiple variables, changes in deviance statistics (Table 11) from the unconditional growth model to the model with age (difference=12.4 with 2 df), and from the model with age to the model with age, subjective norm of family, and native Fort Collins residency (difference=39.1 with 6 df) were tested by chi-square test. The changes were statistically significant (p<0.01).

"Prototypical change trajectories" (Singer & Willett, 2003. p. 110) were calculated using the parameter estimates obtained in the final model. The trajectories illustrate examples of changes in bicycle helmet use for "prototypical individuals" (Singer & Willett, 2003. p. 110) with certain conditions. Equations for the calculations were:

$$\text{Initial Status: } \pi_{0i} = \gamma_{00} + \gamma_{01}\,\text{Age} + \gamma_{02}\,\text{Norm} + \gamma_{03}\,\text{Fort Collins native} + \zeta_{0i}$$

$$\text{Rate of change: } \pi_{1i} = \gamma_{10} + \gamma_{11}\,\text{Age} + \gamma_{12}\,\text{Norm} + \gamma_{13}\,\text{Fort Collins native} + \zeta_{1i}$$

Results are shown in Table 12. For example, if a student was 19 years old, he or she thought that family norm regarding bicycle helmet use was neither positive nor negative, and he or she was not a native Fort Collins resident, the prototypical person wore a bicycle helmet almost every time in elementary school (i.e., initial status is 4.93 on a scale ranging from 1 [Never] to 6 [Every time]). However, bicycle helmet use decreased from 4.93 in elementary school to 3.38 in junior high school, and to 1.83 in high school. In contrast, a prototypical student who was aged 22 years and a native Fort Collins resident, and whose perception toward family norm was high, wore a bicycle helmet more than half of the time in elementary school (i.e., initial status=4.38). Bicycle helmet use increased for the person from 4.38 to 4.47 in junior high school, and to 4.56 to high school. In many cases, trajectories had negative rates of change indicating a decline in bicycle helmet use over time; however, some cases with older age, positive family norm, and native Fort Collins residency showed positive rates of change.

Table 11

Growth Modeling for Past Bicycle Helmet Use Behaviors

		Parameter	Unconditional *mean model*	Unconditional *growth model*	Gender	Age
Fixed effects				Parameter estimate (Standard error)		
Initial status	Intercept	γ_{00}	3.74***	4.60***	4.60***	4.60***
π_{0i}			(0.13)	(0.16)	(0.16)	(0.15)
	Gender	γ_{01}			-0.33 ns	
					(0.31)	
	Age	γ_{02}				-0.37**
						(0.10)
Rate of change	Intercept	γ_{10}		-0.86***	-0.86***	-0.86***
π_{1i}				(0.09)	(0.09)	(0.09)
	Gender	γ_{11}			0.32 ns	
					(0.17)	
	Age	γ_{12}				0.09 ns
						(0.06)
Variance components						
Level 1	Within-person	σ_e^2	2.26***	0.93***	0.93***	0.93***
			(0.19)	(0.11)	(0.11)	(0.11)
Level 2	In initial status	σ_0^2	1.74***	2.61***	2.58***	2.32***
			(0.31)	(0.42)	(0.42)	(0.38)
	In rate of change	σ_1^2		0.58***	0.56***	0.57***
				(0.14)	(0.14)	(0.14)
	Covariance	σ_{01}		-0.51**	-0.48**	-0.43*
				(0.19)	(0.19)	(0.18)
Deviance			1677.3	1545.2	1541.8	1532.8
AIC			1683.3	1557.2	1557.8	1548.8
BIC			1692.1	1574.8	1581.2	1572.2

ns: not significant. *: p<0.05. **: p<0.01. ***: p<0.001.

Table 11

Growth Modeling for Past Bicycle Helmet Use Behaviors (continued)

	Age & Lived in places with laws		Age & Perceived norm of family		Age & Native Fort Collins residents		Final Model
Fixed effects			Parameter estimate (Standard error)				
Initial status							
Intercept	4.60***	Intercept	4.60***	Intercept	4.60***	Intercept	4.60***
	(0.15)		(0.15)		(0.15)		(0.15)
Age	-0.37***	Age	-0.35***	Age	-0.37***	Age	-0.35***
	(0.10)		(0.10)		(0.10)		(0.10)
Past Law	-0.29 ns	Nm Fam	0.16 ns	Native FC	-0.03 ns	Nm Fam	0.16 ns
	(0.39)		(0.14)		(0.42)		(0.14)
						Native FC	0.02 ns
							(0.42)
Rate of change							
Intercept	-0.86***	Intercept	-0.86***	Intercept	-0.86***	Intercept	-0.86***
	(0.09)		(0.08)		(0.09)		(0.08)
Age	0.09 ns	Age	0.11 ns	Age	0.11 ns	Age	0.13*
	(0.06)		(0.06)		(0.06)		(0.06)
Past Law	-0.09 ns	Nm Fam	0.24**	Native FC	-0.43 ns	Nm Fam	0.25**
	(0.23)		(0.08)		(0.24)		(0.08)
						Native FC	0.50*
							(0.23)
Variance components							
Within-person	0.93***		0.93***		0.93***		0.93***
	(0.11)		(0.11)		(0.11)		(0.11)
In initial status	2.31***		2.29***		2.33***		2.29***
	(0.38)		(0.38)		(0.38)		(0.38)
In rate of change	0.57***		0.50***		0.54***		0.47***
	(0.14)		(0.13)		(0.13)		(0.13)
Covariance	-0.44*		-0.48**		-0.43*		-0.48**
	(0.18)		(0.18)		(0.18)		(0.17)
Deviance	1531.4		1512.8		1528.7		1506.1
AIC	1551.4		1532.8		1548.7		1530.1
BIC	1580.7		1562.1		1578.0		1565.2

ns: not significant. *: $p<0.05$. **: $p<0.01$. ***: $p<0.001$.

Table 12.

Prototypical Trajectories Calculated Using the Final Model

Values of variables			Prototypical trajectories	
Age	Subject norm of family*	Native Fort Collins residents**	Initial status***	Rate of change
19	3	Yes	4.95	-1.05
19	3	No	4.93	-1.55
19	6	Yes	5.43	-0.30
19	6	No	5.41	-0.80
22	3	Yes	3.90	-0.66
22	3	No	3.88	-1.16
22	6	Yes	4.38	0.09
22	6	No	4.36	-0.41
24	3	Yes	3.20	-0.40
24	3	No	3.18	-0.90
24	6	Yes	3.68	0.35
24	6	No	3.66	-0.15

* A scale ranged between 1 (a respondent think that his/her family think he/she should not wear a bicycle helmet) and 6 (a respondent think that his/her family think he/she should wear a bicycle helmet every time).
** Native Fort Collins residents lived in the area since he/she was 12 years old or younger
*** An estimated bicycle helmet use frequency for the prototypical person in elementary school. A scale ranged between 1 (did not wear bicycle helmet at all) and 6 (wore every time).

CHAPTER IV

DISCUSSION

Bicycle use for different purposes

Bicycling was a popular transportation mode and recreational activity among the student bicycle riders at Colorado State University (CSU); half of the study respondents used bicycles on a daily basis. In a previous study conducted in Fort Collins (Kakefuda, 2006; Kakefuda et al., in press), 10 of 13 CSU students (76.9%) interviewed reported that they used bicycles every day, a higher proportion than in the present study. The previous study (Kakefuda, 2006; Kakefuda et al., in press) did not ask bicycle use separately for different purposes. Considering that half of participants of the present study rode bicycles almost every weekend or more often for recreation, students interviewed in the previous study might have responded to the question ("How often do you ride a bicycle?") based on combined bicycle use for both purposes. This suggests that bicycle-related research needs to determine bicycle use for different purposes.

The campus of CSU is located in the central area of Fort Collins with the area of approximately one-square mile, and the campus is surrounded by streets with busy car traffic. About half of the study respondents lived in on-campus residential facilities or off-campus housings in the campus neighborhood. Their commuting minutes were shorter than 10 minutes; however, they were likely to be more frequent bicycle users for commuting compared to students who lived in the more distant areas. An increase in risk of bicycle-related injuries among a U.S. national sample of adults was associated with total miles traveled during an average warm month, not commuting distance, after controlling for demographic characteristics, riding surface (roadways, bike-path, etc.), and bicycle types (Rodgers, 1997). Therefore, exposure to the risk of bicycle-related injuries among students who lived on or close to the campus should not be underestimated, given their frequent bicycle use for commuting.

Bicycle helmet use for different purposes

The study revealed an important aspect of bicycle helmet use behaviors among college students: a discrepancy in the behaviors between different bicycle use purposes, commuting and recreation. Results of the study suggest that asking bicycle helmet use for different purposes is critical for bicycle helmet research, at least for research targeting adult bicycle riders.

Six of nine papers on bicycle helmet use among college students asked study participants about bicycle helmet use without specifying purposes (Coron et al., 1996; Fullerton & Becker, 1991; Joly et al., 2000; Page et al., 1996; Patrick et al., 1997; Weiss et al., 2004), and reported proportions of frequent or consistent bicycle helmet users. Everett et al. (1996) asked whether or not respondents considered themselves as "helmet wearers." The meaning of reported 'bicycle helmet use frequency' is not clear in the articles because interpretations of the questions depended on respondents. Given the observed discrepancy in bicycle helmet use between different purposes among the present study participants, simple questions used in the literature such as "How often do you wear bicycle helmet during the past 12 months?" will not provide needed information.

For example, the previous study in Fort Collins (Kakefuda, 2006) asked bicycle helmet use with a question, "In the past 30 days, when you rode bicycle, how often did you wear a helmet?" A total of 5 of 13 (38.5%) CSU students were classified as being at the Maintenance stage based on their responses to the question and other two Stages of Change questions. The percentage obtained in the previous study was close to the percentage of students at the Maintenance stage in the present study *for recreation*, 36.8%, but considerably diverged from the percentage of students at the stage for commuting, 9.0%. The proportion of consistent bicycle helmet users may therefore have been overestimated in the previous study. In summary, the previous study did not capture comprehensive bicycle helmet use among CSU students.

Whether the bicycle helmet use stages for recreation or for commuting, bicycle helmet use rates among CSU students were the same as or higher than reported use rates in the past studies (Coron et al., 1996; Everett et al., 1996; Fullerton & Becker, 1991; Joly et al., 2000; Lutwig et al., 2005; Patrick et al., 1997; Page et al., 1996; Weiss, 1996; Weiss et al., 2004). Bicycle helmet use may vary across universities and colleges depending on factors including the primary purpose of bicycle use, the physical environment (e.g., weather, bicycle lanes on streets), and the community environment including bicycle helmet laws/ordinances. Bicycle helmet interventions need to be tailored based on college characteristics in relation to bicycle use and bicycle helmet use. In the case of CSU students, low use rate of bicycle helmets for commuting among the study participants suggests that increasing bicycle helmet use while commuting should be the primary goal of interventions.

The utility of the Stages of Change model to determine target groups

The study used the Stages of Change model (Grimley et al., 1994; Prochaska & DiClemente, 1983) to classify individual bicycle helmet use behaviors with current behaviors and behavioral intentions. Asking respondents about intentions to consistently wear bicycle helmet as well as current behaviors were important. In this study, a primary difference between the Precontemplation and Contemplation stages was whether they expressed behavioral intentions to consistently wear bicycle helmets in the future. Current bicycle helmet use between the two groups were similar: most of participants at the Precontemplation stage and all of those at the Contemplation stage never or rarely used bicycle helmets. Nevertheless, the two groups were different as shown in results of proportional odds regression models and comparisons across five different stage groups. The study results provide supporting evidence for the utility of the Stages of Change model to classify individual bicycle helmet use behaviors. In addition, when analyzing the data with proportional odds regression using reported bicycle helmet use (frequency) as outcome variables, not stages defined by the Stage of Change model, patterns of associations between the outcome variables and other variables differed (Appendix E) from the patterns found in the present study. When bicycle helmet use was used as outcome variables, only the factor of 'emotional importance of bicycle helmet use' was associated with bicycle helmet use for commuting (Appendix E). In the recreation model, two factors which were significant in the model with stages, 'inconvenience of bicycle helmet use' and 'perceptions toward control on the road' were not associated with bicycle helmet use frequency; however, in the model with helmet use frequency, the factor of 'feeling comfortable with bicycle helmet use and promotion efforts' was significant

(Appendix E). Bicycle helmet use stages (combinations of behaviors and behavioral intentions) and bicycle helmet use frequency (behaviors) may capture different aspects of the behavior. From a methodological perspective of measuring bicycle helmet use behaviors, investigating differences between the Stages of Change and bicycle helmet use frequency is important.

In general, behavioral intentions were associated with behaviors, although the associations tended to be weaker than associations between attitudes and intentions due perhaps to barriers impeding actual behavioral changes (Kim & Hunter, 1993). People who have expressed intentions to change behaviors have different attitudes than people with no intention to change (Grimley et al., 1994). Comparisons of five groups with different bicycle helmet use behaviors and intentions in the study provided information about which groups should be the primary target of future interventions. Expressing intentions to consistently wear bicycle helmets differentiated groups. The group at Precontemplation-commuting & Maintenance-recreation (i.e., no intention of consistent bicycle helmet use for commuting but always using a bicycle helmet for recreation) differed from Contemplation/Preparation-commuting & Maintenance-recreation (i.e., having intentions of consistent bicycle helmet use for commuting with current inconsistent use but always using a bicycle helmet for recreation). Specifically, the latter groups were closer to the group of Maintenance-commuting & Maintenance-recreation (i.e., always using a bicycle helmet for commuting and for recreation) in regards to the importance of bicycle helmet use; however they were not convinced of the necessity of bicycle helmet use for short distance trips including commuting. The Contemplation/Preparation-commuting & Maintenance-recreation group may be an important primary target of future interventions. The group expressed a willingness to always wear bicycle helmets for commuting; they may therefore become consistent users if they were convinced of the necessity of consistent use for commuting.

Given the knowledge of associations between attitude, behavioral intention, and behavior (Kim & Hunter, 1993), promoting bicycle helmet use for commuting primarily among the Precontemplation-commuting & Maintenance-recreation group may be difficult. The group expressed no intention to consistently wear bicycle helmets for commuting and their attitudes with regard to bicycle helmet use for that purpose were as low as the attitudes among the Precontemplation-commuting & Precontemplation-recreation group. Self-perception (Bem, 1972) and/or cognitive dissonance (Festinger & Carlsmith, 1959) might facilitate them forming attitudes less favorable for bicycle helmet use for commuting. Behaviors of students in the group were clearly discrepant between bicycle use purposes. To explain or justify the discrepancy, when they realized the discrepancy or were asked reasons of the discrepancy, they were likely to report negative attitudes toward bicycle helmet use for commuting. Thereafter, expressing negative attitudes was likely to crystallize the attitudes as well as lack of intention to use in the future. From the viewpoint of attitude formation and attitude change through self perception, it is appropriate to tailor promotion messages targeting students who have any intention to wear bicycle helmets for either purpose, including the Contemplation-both purposes group and Preparation-both purposes group. Even the group of Precontemplation-commuting & Contemplation/Preparation-recreation may be more approachable than the Precontemplation-commuting & Maintenance-recreation group, because among the former group, the discrepancy in bicycle helmet use for two purposes may not be clear to themselves, leading to less crystallized attitudes than the latter group.

It should be noted that the study does not assume that behaviors will change through stages, such as from the Precontemplation stage to the Contemplation stage or from the Preparation to the Action stages. Individual bicycle helmet use may change from the Precontemplation stage to the Maintenance stage, if triggered by specific events. The original Stages of Change model (Prochaska & DiClemente, 1983) assumed stepwise changes and proposed intervention strategies accordingly. However, smoking cessation researchers have found that the assumption of linear change might not be relevant; smokers may skip stages, for example, from the Precontemplation stage to the Action stage (West, 2005). In research on bicycle helmet use and other areas of injury prevention and safety promotion, applications of psychosocial theories are limited and no studies were identified which applied the Stages of Change model (Trifiletti, Gielen, Sleet, & Hopkins, 2005), except one (Weiss et al., 2004). The present study provided support for the utility of the model in terms of classifying individuals based on intentions and current behaviors. More research is needed using the model in other areas of injury prevention.

The utility of semantic differential to understand the multidimensionality of attitude

Semantic differential scales used in the study revealed the multidimensionality of attitudes toward bicycle helmet use and bicycle helmet promotions on campus, as posited by Osgood (1952). The scales of 'uncomfortable - comfortable' comprised a separate factor. In addition, within the factors of 'bicycle helmet use for commuting' and 'increasing bicycle helmet use among CSU student,' differences were noticeable between the scales of 'unnecessary - necessary' and 'ineffective - effective' and other three scales, 'bad - good,' 'foolish - smart' and 'harmful - beneficial.' The results suggest that there are at least three potential dimensions in relation to bicycle helmet use behaviors and promotions.

Two sets of semantic differential scales, 'bicycle helmet use for commuting' and 'bicycle helmet use for recreation,' showed different perceptions toward the necessity of bicycle helmet between the two bicycle ride purposes. Even the group who did not expressed an intention to consistently wear bicycle helmets for recreation acknowledged the necessity of use for that purpose; in contrast, groups who did not intended to use helmets for commuting thought that helmets were neither necessary nor effective for commuting. Awareness raising of the necessity of bicycle helmet use for commuting should be an essential component of any bicycle helmet interventions targeting CSU students. Disseminating information of bicycle-related injuries around the campus and on city roads may be effective in informing students of the risk of bicycle-related TBIs during commuting.

For development and application of community interventions, it is important to collect and disseminate local data to the community (Oetting et al., 1995). Community residents expressed preference for local data; for example, school district-level data was preferred to municipality-level, and municipality-level over county-level data, as safety information in relation to traffic injury prevention (Ytterstad, 2003). In Fort Collins and surrounding areas, residents and workers including safety and health professionals were not aware of the availability of local data (Kakefuda, 2006). Improving local data collection and disseminating systems on traffic-related injuries will contribute to bicycle helmet promotion efforts as well as other traffic-related safety promotions.

Lack of the knowledge and awareness about injury risks in commuting environments may not be the only reason for the lower perception toward need of bicycle helmet use for commuting. Similar to the concept proposed by Will (2006) as the 'immunity fallacy' among parents regarding child restraint seat use, bicycle riders may underestimate the risk of injuries on bicycles because of optimistic bias (Weinstein, 1980); familiarity with the commuting environment; a feeling of invincibility reinforced by day-to-day experience of no-injurious incidents; and, overall low base rates of bicycle-related injuries (total odds of dying by bicycle-related injury in the U.S. is 1 in 4,919 compared to 1 in 84 in motor-vehicle related incidents [National Safety Council, 2007]). Providing injury data to the students may not be effective enough to change perceptions toward personal risks of bicycle-related injuries during commuting because they are likely to think 'it will not happen to me.' Risk communication research to find media and messages appropriate to a target group is a key to developing effective promotion programs. If bicycle riders see injuries as a personal threat, they may be more likely to pay attention to and consider promotion messages cognitively. The 'central route of information processing' has higher likelihood of attitude changes following a message exposure compared to 'peripheral information processing' without cognitive processing of massages (Petty, Cacioppo, & Schumann 1983). Fear messages have been considered to be effective in increasing personal relevance and leading to attitude changes; however, a meta-analysis suggested that it depended on strength of fear evoked by a message and combinations of information coupled with fear messages (Witte & Allen, 2000). In the areas of bicycle safety and other unintentional injury prevention research, applications of risk communication approaches to examine effects of messages are limited (Girasek, 2006; Rossiter & Thornton, 2004), and more research is necessary in the field.

There is another potential strategy to induce the central route processing of information by increasing personal relevancy of the issue: making the importance of safety salient among college student bicycle riders. In the proportional odds regression models for commuting and recreation, the factor of 'emotional importance of bicycle helmet use' was associated with bicycle helmet use stages above and beyond the effects of other variables. Perceived norms of others and 'peace of mind' were associated with higher stages. Emphasizing positive norms of others may be useful in increasing the awareness of the importance of preventing bicycle-related TBIs.

To promote the importance of safety, it is essential to understand how 'injury experiences of people respondents knew' operate in relation to bicycle helmet use behavior. The variable was associated with many variables, while another variable 'injury experiences by self' was associated with only few variables. The study participants who were at the higher stages for both bicycle riding purposes were more likely to know others injured in bicycle-related incidents. The results are consistent with findings reported by Everett et al. (1996), but inconsistent with a finding reported from the University New Mexico (Fullerton & Becker, 1991) in which injury experiences by self were related to current bicycle helmet use.

Individuals who used bicycle helmets more often and knew people injured on bicycles may have been in an environment in which risky behaviors were the norm and therefore injury risks were high. However, bicycle use frequency for commuting and for recreation did not differ across groups with different injury experience patterns. Another possible interpretation is that some individuals used bicycle helmets more often than others because they knew more people who were injured in bicycle-related incidents, and acknowledged the importance of bicycle helmet use. Direction of causality of the association is not clear, but the knowledge may be useful to tailor promotion messages.

Perea and Slater (1999) found that televised messages on drinking-and-driving emphasizing risks to family and friends in the car were more persuasive than messages emphasizing risks to self in the car irrespective of gender and ethnicity of an adult audience of Anglo and Mexican Americans. In another study, high school students responded differently by gender to alcohol-related public service announcements (PSAs) and advertisements about beer (Andsager, Austin, & Pinkleton, 2002). Female students perceived collectivistic PSAs (e.g., mothers mourning for her son who died in an alcohol-related incident) to be more trustworthy and persuasive than male students (Andsager et al., 2002). Results of the studies will not translate directly to bicycle helmet use. However, it is important to examine the effects of messages which feature possible bicycle-related TBIs among people important to college students, and which focus on emotions of important others to be evoked in the event where students sustain a head injury. Additionally, impacts of age, race/ethnicity, and gender on message effects should be considered in future studies. Given the results of this study that participants perceived family norms with regard to bicycle helmet use to be high irrespective of stages, future research should test effectiveness of messages using family members, and compare them with messages which feature bicycle-related TBIs from the first-person perspective.

Messages from the first-person perspective (e.g., a PSA depicting a young drunk driver who was killed in a car crash) may not be interpreted as expected, because the audience may attribute the death to driving skills of the driver, not drinking-and-driving, and feel that they can avoid the consequence due to better driving skills (Harre, Foster, &

O'Neill, 2005). Fundamental attribution error (Ross, 1977) and optimistic bias (Weinstein, 1980) may be factors behind this responses. The phenomena need to be studied more thoroughly; this may explain why injury experiences of respondents were not associated with bicycle helmet use and other variables in the present study.

Factors extracted from semantic differentials of 'increasing bicycle helmet use among CSU students' and 'a bicycle helmet regulation on the CSU campus' provide useful information regarding preferences about types of bicycle helmet promotions among students. Students, even those who always wore bicycle helmets for commuting, did not favor bicycle helmet regulations on the campus. Regardless of bicycle helmet use and intentions, they did not feel comfortable with regulations on the college campus. The results were consistent with other college student bicycle helmet studies (Joly et al., 2001; Lutwig et al., 2005), and consistent with a previous study conducted in Fort Collins which found the community climate more favorable toward education than regulation (Kakefuda 2006; Kakefuda et al., in press).

Modeling bicycle helmet use behavior

The study included variables found to be associated with bicycle helmet use or other traffic safety behaviors. The models fitted and pseudo R-squared suggested the variables included in the models explained a sizable portion of variability in bicycle helmet use stages among the study participants. However, patterns of associations between variables and bicycle helmet use stages differed between models of commuting and recreation.

Two attitude factors, 'emotional importance of helmet use' and 'inconvenience of bicycle helmet use,' were associated with bicycle helmet use stages of both bicycle riding purposes after controlling for other variables and factors. Feeling of inconvenience attached to bicycle helmet use may not be easy to change directly by promotion efforts. Even the student riders who always wore bicycle helmets for commuting and for recreation (the group of Maintenance-both purposes) acknowledged inconvenience of bicycle helmet use. This group reported that bicycle helmets could mess up hair, that wearing bicycle helmets was not comfortable, and that carrying a helmet around was not convenient. Nevertheless, the group used bicycle helmets always because they considered the behavior important. If students do not think bicycle-related injuries are personally relevant and think bicycle helmet use is not important, changing negative attitudes would be difficult and physical/environmental modifications such as modifying designs of bicycle helmets and/or providing bicycle helmet lockers on campus would not be successful. Long-term and less salient rewards tend to be less valued than immediate and salient rewards (Blomquist, 1986; Herrnstein, Loewenstein, Prelec, & Vaughan, 1993). In the case of bicycle helmet use, preventing TBIs is the long-term reward for the behavior; however, the reward is usually not salient because injurious incidents are unpredictable. In contrast, non-use of a bicycle helmet offers immediate rewards; bicycle riders can avoid inconvenience and discomfort associated with bicycle helmet use. It is difficult to change behaviors solely by physical/environmental modifications if bicycle riders did not feel bicycle helmet use is necessary.

In addition, motivation for reducing cognitive dissonance (Festinger & Carlsmith; 1959) may also cause a feeling of inconvenience among students who never or inconsistently wore bicycle helmets. They reported bicycle helmet use to be 'good,' 'smart' and 'beneficial,' but they did not use the equipment. The incongruity between attitude and behavior may drive them to reduce dissonance feeling. Inconvenience of bicycle helmet use can be a plausible excuse for their behaviors, i.e., inconsistent use or non-use of bicycle helmets. If this should be the case, trying to change the feeling of inconvenience may be ineffective, or may lead the negative attitudes to become more crystallized.

In the proportional odds regression model for bicycle helmet use for recreation, a semantic differential factor 'Helmet use for commuting' and bicycle helmet use stages for recreation were negatively associated. The association was unexpected. This may be a reflection of the asymmetric patterns of bicycle helmet use stages between two bicycle riding purposes. Many students wore bicycle helmets more frequently for recreation than for commuting, with only two exceptions. No one always used bicycle helmets for commuting but never for recreation. As a result, it was common for participants in the study to have positive attitudes toward recreational bicycle helmet use while having less positive attitudes toward bicycle helmet use for commuting. In contrast, it was rare to observe individuals who had positive attitudes toward bicycle helmet use for commuting and negative attitudes toward bicycle helmet use for recreation.

Perceptions toward risk of bicycle-related head injuries were not associated with bicycle helmet use in regression models. Contrary to the expected direction of association, individuals perceiving themselves as safer and more skilled bicycle riders wore bicycle helmets more often for recreation compared to those with less competence. Reasons for the results are unknown; however, it may be related to the instruments used to measure perceptions toward risks. The study used 'direct measures' of risk perceptions (Klein & Helweg-Larsen, 2002). With the measure, a respondent estimates his or her likelihood of involving in an event relative to a target (e.g., peer bicycle riders). Responses to direct measures may vary depending on perceptions among respondents toward a target group. Some respondents may perceive peers' risk of involving in an injurious event and competence on the road lower than other respondents. Perceptions toward self may vary due partly to the differences in perceptions toward peers. To avoid the variability, 'indirect measures' were also used (Klein & Helweg-Larsen, 2002). With the measure, a respondent estimates two types of likelihood: the probability of his or her own being involved in an event, and the probability of the event in general. By subtracting the two estimates, comparative risk can be calculated (Klein & Helweg-Larsen, 2002). A meta-analysis found a stronger correlation between optimism (biased risk perception) and personal control feeling among studies using direct measures (Klein & Helweg-Larsen, 2002). Results of this study might have been different if indirect measures were used.

Effects of bicycle helmet use in the past

The study provided knowledge that frequent bicycle helmet use in the past, from elementary school through high school, was directly or indirectly associated with current use. On average, bicycle helmet use decreased over time; the result is consistent with another study which presented lower bicycle helmet use rates among teenagers and college-age youths compared to children (Rodgers, 2000). It is important, however, to notice in the study that some participants remained to be frequent bicycle helmet users over time, while others presented consistent declines with different shapes of trajectories. Age, perceived norm of family, and having lived in Fort Collins and surrounding areas since 12 years old or younger were associated with the differences across individuals. The results suggest that norms of family and a community in which individuals grow up might have influences on bicycle helmet use behaviors and attitudes among children and adolescents, and keep them from abandoning the use behavior once they acquired. The results gave support for the importance of family norm with regard to bicycle helmet use and the importance of increasing use among adults including college students as community residents and/or (future) parents.

More studies are necessary to understand changes in bicycle helmet use within individuals over time. This study did not include any variables which might explain changes in use within individuals, including perceived norms of friends regarding bicycle helmet use in elementary, junior high, and high school.

Limitations

The study used self-report to assess bicycle helmet use. Self-report has been shown to increase bicycle helmet use rates compared to rates obtained in observational studies (Ni, Sacks, Curtis, Cieslak, & Hedberg, 1997). Study participants might have overestimated current and past bicycle helmet use.

In addition, how to perceive questions of a survey and how to respond might differ across different bicycle helmet use groups, and might lead different degrees of recall bias. Answering questions is a series of cognitive processes (Jobe, 2003), and motivation to comprehend and respond to questions may vary across respondents due to the degree of relevance of a topic. If students wear bicycle helmets, they might perceive questions of the study as more relevant to them, comprehend questions cognitively, and try to estimate accurate bicycle helmet use, compared to those who do not use bicycle helmets. Differences in information processing may cause differences in accuracy of self-reported bicycle helmet use in the past.

The study did not ask participants when they experienced bicycle-related head injuries and/or when they heard about head injury experiences from people they knew. Without these questions, whether injury incidents occurred before or after bicycle helmet use started is unknown. These questions also might have helped to elucidate differences in injury experiences among respondents which were observed. International students in the study experienced more bicycle-related head injuries than U.S. students. There is a possibility that international students may sustain more bicycle-related TBIs in the U.S. than U.S. students due to different traffic rules and traffic behaviors between U.S. and home countries. This information may be quite important in developing intervention programs on college campuses.

Conclusions and future directions

The study examined behaviors, attitudes, and experiences in relation to bicycle helmet use among Colorado State University (CSU) students. Findings are informative in terms of methodology of bicycle helmet research and intervention program development.

From the methodological viewpoint, first, the study clearly showed that asking bicycle helmet use for different riding purposes is critical. Bicycle use and bicycle helmet use patterns found in the study cannot be generalized to other colleges: other universities and colleges may have unique patterns of bicycle use and bicycle helmet use depending on physical and social environments.

Secondly, the Stages of Change model was useful in this study. The classification approach which combined current behaviors and future intentions will be useful in determining target groups and developing intervention programs appropriate to groups with different behaviors and attitudes.

Thirdly, semantic differentials with multiple response scales were useful in understanding multidimensionality of bicycle helmet-related attitudes. The approach may help focus on specific attitudinal dimensions which hamper or encourage college students to use bicycle helmets.

Lastly, the study found that bicycle helmet use behaviors were associated with many variables which captured different aspects of behaviors, attitudes and perceptions, and that the variables were correlated each other. Bicycle helmet research needs to include multiple variables, not only one or two variables of interest, to obtain a clearer description of behaviors among specific groups.

From the perspective of intervention program development targeting CSU student bicycle riders, it is clear that increasing bicycle helmet use for commuting should be a primary goal. One target group is students who always or inconsistently wear bicycle helmets for recreation and have an intention to use bicycle helmets for commuting. Interventions might aim to convince these students of the necessity of bicycle helmet use during commuting, through presenting bicycle-related injury data around the campus and in the city. To increase a feeling of personal relevance of bicycle-related TBI incidents and to facilitate consideration of promotion messages, cue messages could be used. The cues might be tailored to convey messages which direct student attentions to emotional responses among family members if the student is injured. Messages might also cue on the emotions the student would have if a family member suffers a TBI in a bicycle-related incident.

In order to create effective messages for an intervention, experimental studies should be conducted. Topics which might be examined in a series of experiments include: effects of different types of local bicycle-related injury information (e.g., city-wide data, data collected on and around CSU campus) on attitudes and intentions with regard to bicycle helmet use for commuting; effects of different presentations about consequences of TBIs and about the effectiveness of a bicycle helmet in preventing TBIs; and, effects of different types of cue messages. These studies would contribute to risk communication research and bicycle safety research as well as to developing intervention programs on CSU campus.

Even if messages show effectiveness in changing attitudes and in increasing intentions to consistently wear bicycle helmets within laboratory settings, the messages may not lead to an increase in bicycle helmet use on CSU campus due to other existing barriers to actual behavior changes. Other strategies including free or discounted bicycle helmet distributions and educational presentations at health-related campus events may be helpful to lower barriers. Bicycle helmet promotions efforts have been conducted on the campus sporadically by the university health center and police department; however, the effectiveness of the events is unknown. Evaluating current efforts is important to develop a comprehensive program with effective messages. In addition, establishing methodologies to assess bicycle helmet use changes among CSU students and to record bicycle-related TBIs among the population is necessary.

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References

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, 50, 179-211.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Ajzen, I., & Fishbein, M. (2000). Attitudes and the attitude-behavior relation: Reasoned and automatic processes. *European Review of Social Psychology*, 11.

Andsager, J.L., Austin, E.W., & Pinkleton, B.E., (2002). Gender as a variable in interpretation of alcohol-related messages. *Communication Research*, 29, 246-269.

Attewell, R.G., Glase, K., & McFadden, M. (2001). Bicycle helmet efficacy: A meta-analysis. *Accident Analysis and Prevention,* 33, 345-352.

Bem, D. J. (1972). *Self-perception theory.* In L. Berkowitz (Ed.), Advances in Experimental Social psychology, Vol. 6, 1-62. New York: Academic Press.

Bernstein, J.D., Harper, M.A., Pardi, L.A., & Christopher, N.C. (2003). Parental knowledge and children's use of bicycle helmets. *Clinical Pediatrics,* 42, 673-677.

Bicycle Helmet Safety Institute (2008). *Helmet Laws for Bicycle Riders.* Retrieved January 18, 2008 at http://www.helmets.org/mandator.htm.

Blomquist, G. (1986). A utility maximization model of driver traffic safety behavior. *Accident Analysis and Prevention,* 18, 371-375.

Bolen, J.R., Kresnow, M., & Sacks, J.J. (1998). Reported Bicycle Helmet Use Among Adults in the United States. *Archives of Family Medicine*, 7, 72-77.

Budd, R.J., North, D., & Spencer, C. (1984). Understanding seat-belt use: A test of Bentler and Speckart's extension of the 'theory of reasoned action. *European Journal of Social Psychology*, 14, 69-78.

Bungum, T.J. & Bungum, N.W. (2003). Predictors of bicycle helmet usage among seniors. *Journal of Community Health,* 28, 221-228.

Centers for Disease Control and Prevention (CDC). (2007). *Physical Activity for Everyone: Tips for Being More Active.* Retrieved May 28, 2007 from http://www.cdc.gov/nccdphp/dnpa/physical/life/tips.htm.

City of Fort Collins. (2007). *Smarttrips.* Retrieved May 29, 2007 from http://www.fcgov.com/smarttrips/

Cody, B.E., Quraishi, A.Y., & Mickalide, A.D. (2004). *Headed for Injury: An Observational Survey of Helmet Use among Children Ages 5 to 14 Participating in Wheeled Sports.* Washington D.C.: National SAFE KIDS Campaign.

Coron, J. & McLaughlin, G. (1996). Factors influencing use of bicycle helmets among undergraduate students. *Journal of American College Health*, 44, 294-297.

Curnow, W.J. (2003). The efficacy of bicycle helmets against brain injury. *Accident Analysis and Prevention,* 35, 287-292.

Dannenberg, A.L., Cote, T.R., Kresnow, M., Sacks, J.J., Lipsitz, C.M., & Schmidt, E.R. (1993). Bicycle helmet use by adults: the impact of companionship. *Public Health Report.* 108(2), 212-217.

DeJoy. D.M. (1989). The optimism bias and traffic accident risk perception. *Accident*

Analysis & Prevention, 21, 333-340.

DiGuiseppi, C.G., Rivara, F.P., & Koepsell, T.D. (1990). Attitudes toward bicycle helmet ownership and use by school-age children. *American Journal of Diseases of Children*, 144, 83-86.

Ehrlich, P.F., Helmkamp, J.C., Williams, J.M., Haque, A., & Furbee, P.M. (2004). Matched analysis of parent's and children's attitudes and practices towards motor vehicle and bicycle safety: An important information gap. *Injury Control and Safety Promotion,* 11, 23-28.

Ehrlich, P.F., Longhi, J., Vaughan, R., & Rockwell, S. (2001). Correlation between parental perception of bicycle helmet use and riding practices: implications for designing injury prevention strategies. *Journal of Pediatric Surgery*, 36, 763-766.

Everett, S.A., Price, J.H., Bergin, D.A., & Groves, B.W. (1996). Personal goals as motivators: Predicting bicycle helmet use in university students. *Journal of Safety Research,* 27, 43-53.

Festinger, L. & Carlsmith, J. M. (1959). Cognitive consequences of forced compliance. *Journal of Abnormal and Social Psychology*, 58, 203-211.

Finnoff, J.T., Laskowski, E.R., Altman, K.L., & Diehl, N.N. (2001). Barriers to bicycle helmet use. *Pediatrics,* 108, 4-7.

Forthofer, M.S. (2000). Using audience-segmentation techniques to tailor health behavior change strategies. *American Journal of Health Behavior,* 24, 36-43.

Fullerton, L., & Becker, T. (1991). Moving targets: Bicycle-related injuries and helmet use among university students. *Journal of American College health,* 39, 213-217.

Gielen, A.C., Joffe, A., Dannenberg, A.L., Wilson, M.E.H., Belienson, P.L., & DeBoer,

M. (1994). Psychosocial factors associated with the use of bicycle helmets among children in counties with and with out helmet use laws. *Journal of Pediatrics,* 124, 204-210.

Girasek, D.C. (2006). Would society pay more attention to injuries if the injury control community paid more attention to risk communication science? *Injury Prevention,* 12, 71-73.

Grimley, D., Prochaska, J.O., Velicer, W.F., Blais, L.M., & DiClemente, C.C. (1994). The Transtheoretical Model of Change. In Brinthaupt, T.M. (Ed.) *Changing the Self: Philosophies, Techniques, and Experiences.* Albany State University of New York Press.

Harre, N., Foster, S., & O'Neill, M. (2005). Self-enhancement, crash-risk optimism and the impact of safety advertisements on young drivers. *British Journal of Psychology,* 96, 215-230.

Helweg-Larsen, M. & Shepperd, J.A. (2001). Do moderators of the optimistic bias affect personal or target risk estimates?: A review of the literature. *Personality and Social Psychology*, 5, 74-95.

Herrnstein, R.J., Loewenstein, G.F., Prelec, D., & Vaughan, W. (1993). Utility maximization and melioration: Internalities in individual choice. *Journal of Behavioral Decision Making,* 6, 149-185.

Howland, J., Sargent, J., Weitzman, M., Mangione, T., Ebert, R., Mauceri, M., & Bond, M. (1989). Barriers to bicycle helmet use among children: Results of focus groups with fourth, fifth, and sixth graders. *American Journal of Diseases of Children*, 143, 741-744.

Institute of Medicine (IOM). (2002). Health communication campaigns exemplar. In *Speaking of Health: Assessing Health Communication Strategies for Diverse Populations.* The National Academies Press, Washington, D.C.

Institute of Transportation Management, Colorado State University. (2004). *Fort Collins Bicycle Helmet Usage Survey 2004.*

Insurance Institute for Highway Safety. (2007). *Fatality Facts 2005 - Bicycles.* Retrieved May 28, 2007 from http://www.iihs.org/research/fatalityfacts/bicycles.html.

Janz, N.K., Champion, V.L., & Strecher, V.J. (2002). The Health Belief Model. In (Eds.) Glanz, K., B.K. Rimer., Lewis, F.M. *Health Behavior and Health Education: Theory, Research, and Practice* (3rd ed). San Francisco: CA, Jossey-Bass.

Jobe, J.B. (2003). Cognitive psychology and self-reports: Models and methods. *Quality of Life Research,* 12, 219-227.

Joly, B.M., McDermotto, R.J., & Westhoff, W.W. (2000). Transportation practices of college students: Effects of gender and residential status on risk of injury. *The International Electronic Journal of Health Education,* 3, 117-125.

Jones, C.S., King, W., Poteet-Johnson, D., & Wang, M. (1993). Prevention of bicycle-related injuries in childhood: Role of the caregiver. *Southern Medical Journal,* 86, 859-864.

Kakefuda, I. (2006). *Bicycle helmet use attitudes and behaviors among adults: An exploratory study of Community Readiness and Stages of Change.* Master's thesis, Psychology Department, Colorado State University.

Kakefuda, I., Stallones, L., & Gibbs, J. (2008, in press). Readiness for community-based bicycle helmet use programs: A study using community- and individual-level readiness models. *Journal of Health Psychology.* 13.

Khambalia, A., MacArthur, C., & Parkin, P.C. (2005). Peer and adult companion helmet use is associated with bicycle helmet use by children. *Pediatrics,* 116, 939-942.

Kim, M., & Hunter, J.E. (1993). Relationships among attitudes, behavioral intentions, and behavior: A meta-analysis of past research, Part 2. *Communication Research,* 20, 331-364.

Klein, C.T.F. & Helweg-Larsen, M. (2002). Perceived control and the optimistic bias: A meta-analytic review. *Psychology and Health,* 17, 437-446.

Lajunen, T. & Räsänen, M (2001). Why teenagers owning a bicycle helmet do not use their helmets. *Journal of Safety Research,* 32, 323-332.

Lajunen, T. & Räsänen, M (2004). Can social psychological models be used to promote bicycle helmet use among teenagers? A comparison of the Health Belief Model, Theory of Planned Behavor and the Locus of Control. *Journal of Safety Research,* 35, 115-123.

League of American Bicyclists. (2003). *Bicycle Friendly Communities 2003: Enhancing Cities through Cycling.* Retrieved May 29, 2007 from http://www.bicyclefriendlycommunity.org/pressrelease3.htm.

League of American Bicyclists. (2005). *Fort Collins, Colorado.* Retrieved May 29, 2007 from http://www.bicyclefriendlycommunity.org/Images/bfc_pdf_pages /fort_collins.pdf.

Liller, K.D. & Morissette, B. (1998). Middle school students and bicycle helmet use: Knowledge, attitudes, beliefs, and behaviors. *Journal of School Health,* 68, 325-328.

Logan, P., Leadbetter, S., Gibson, R.E., Schieber, R., Branche, C., Bender, P., Zane, D., Humphreys, J., and Anderson, S. (1998). Evaluation of a bicycle helmet giveaway program: Texas, 1995. *Pediatrics*, 101, 578-582.

Loubeau, P.R. (1999). Exploration of the barriers to bicycle helmet use among 12 and 13 year old children. *Accident Analysis & Prevention,* 32, 111-115.

Ludwig, T.D., Buchholz, C., & Clarke, S.W. (2005). Using social marketing to increase the use of helmets among bicyclists. *Journal of American College health,* 54, 51-58.

McCoy. (2002). Development and pilot testing of a bicycle safety questionnaire for adult bicyclists. *Public Health Nursing,* 19, 440-450.

Miller, P.A., Binns, H.J., & Christoffel, K.K. (1996). Children's bicycle helmet attitudes and use: Association with parental rules. *Archives of Pediatrics & Adolescent Medicine,* 150, 1259-1264.

Montaño, D.E. & Kasprzyk, D. (2002). The Theory of Reasoned Action and the Theory of Planned Behavior. In (Eds.) Glanz, K., B.K. Rimer., Lewis, F.M. *Health Behavior and Health Education: Theory, Research, and Practice* (3rd ed). San Francisco: CA, Jossey-Bass.

National Bicycle Dealers Association (2006). Industry Overview 2006. Retrieved June 6' 2007 from http://nbda.com/page.cfm?PageID=34.

National Safety Council. (2007). Odds of dying. http://www.nsc.org/lrs/statinfo/odds.htm.

National Sporting Goods Association. (2007). *Ten-Year History of Selected Sports Participation.* Retrieved May 28, 2007 from http://www.nsga.org/public/pages/index.cfm?pageid=153.

Ni, H., Sacks, J.J., Curtis, L., Cieslak, P.R., & Hedberg, K. (1997). Evaluation of a statewide bicycle helmet law via multiple measures of helmet use. *Archives of Pediatrics & Adolescent Medicine,* 151, 59-65.

O'Callaghan, F.V., & Nausbaum, S. (2006). Predicting bicycle helmet wearing intentions and behavior among adolescents. *Journal of Safety Behavior*, 37, 425-431.

Oetting, E.R., Donnermeyer, J.F., Plested, B.A., Edwards, R.W., Kelly, K., & Beauvais, F. (1995). Assessing community readiness for prevention. *The International Journal of the Addiction*, 30(6), 659-683.

Oetting, E.R., Jumper-Thurman, P., Plested, B.A., & Edwards, R.W. (2001). Community readiness and health services. *Substance Use & Misuse*, 36 (6&7), 825-843.

Office of Budgets and Institutional Analysis at CSU (OBIA). (2006). *Colorado State University The Fact Book 2006-2007.* Retrieved May 30, 2007 from http://www.colostate.edu/Depts/OBIA

Ortega, H.W., Shields, B.J., & Smith, G.A. (2004). Bicycle-related injuries to children and parental attitudes regarding bicycle safety. *Clinical Pediatrics*, 251-259.

Osgood, C.E. (1952). The nature and measurement of meaning. *Psychological Bulletin,* 49, 197-237.

Page, R.M., Follett, T.K., Scanlan, A., Hammermeister, J., & Friesen, R. (1996). Perceived barrier, risk perception, and social norm attitude about wearing helmets among college students. *American Journal of Health Behavior*, 20, 33-40.

Patrick, K., Covin, J.R., Fulop, M., Calfas, K., & Lovato, C. (1997). Health risk behaviors among California college students, *Journal of American College Health,* 45, 265-272

Parvanta, C.F. (2000). Health communication at the Centers for Disease Control and Prevention. *American Journal of Health Behavior,* 24, 18-27.

Perea, A., & Slater, M.D. (1999). Power distance and collectivist/individualist strategies in alcohol warnings: Effects by gender and ethnicity. *Journal of Health Communication*, 4, 295-310.

Petty, R.E., Cacioppo, J.T., & Schumann, D. (1983). Central and peripheral routes to advertising effectiveness: The moderating role of involvement. *Journal of Consumer Research*, 10, 135-146.

Prochaska, J.O. & DiClemente, C.C. (1983). Stages and processes of self-change of smoking: toward an integrative model of change. *Journal of Counseling and Clinical Psychology*, 31(3), 390-395.

Prochaska, J.O., Redding, C.A., & Evers, K.E. (2002). The Transtheoretical model and Stages of Change. In (Eds.) Glanz, K., B.K. Rimer., Lewis, F.M. *Health Behavior and Health Education: Theory, Research, and Practice* (3rd ed). San Francisco: CA, Jossey-Bass.

Prothro, E.T. & Keehn, J.D. (1957). Stereotypes and semantic space. *Journal of Social Psychology, 45,* 197-209.

Pucher, J., Komanoff, C., & Schimik, P. (1999). Bicycling renaissance in North America?: Recent trends and alternative policies to promote bicycling. *Transportation Research Part A*, 33, 625-654.

Quine, L., Rutter, D.R., & Arnold, L. (1994). Predicting and understanding safety helmet use among schoolboy cyclists: A comparison of the Theory of Planned Behaviour and the Health Belief Model. *Psychology and Health,* 13, 251-269.

Rivara, F.P., Thompson, D.C., Patterson, M.Q., & Thompson, R.S. (1998). Prevention of bicycle-related injuries: Helmets, education, and legislation. *Annual Review of Public Health,* 19, 293-318.

Rivara, F.P., Thompson, D.C., Thompson, R.S., Rogers, L.W., Alexander, B., Felix, D., & Bergman, A.B. (1994). The Seattle children's bicycle helmet campaign: Changes in helmet use and head injury admissions. *Pediatrics*, 93, 567-569.

Rodgers, G.B. (1997). Factors associated with the crash risk of adult bicyclists. *Journal of Safety Research*, 28, 233-241.

Rodgers, G.B. (2000). Bicycle and bicycle helmet use patterns in the United States in 1998. *Journal of Safety Research*, 31, 149-158.

Rodgers, G.B. (2002). Effects of state helmet laws on bicycle helmet use by children and adolescents. *Injury Prevention,* 8, 42-46.

Rosenstock, I.M. (1974). Historical origins of the Health Belief Model. *Health Education Monographs*, 2, 328-335.

Ross, L. (1977). The intuitive psychologist and his shortcomings: Distortions in the attribution process. L. Berkowitz (Ed.), *Advances in experimental social psychology* (vol. 10). New York: Academic Press.

Rossiter, J.R., & Thornton, J. (2004). Fear-pattern analysis supports the fear-drive model for antispeeding road-safety TV ads. *Psychology & Marketing*, 21, 945-960.

Royal, S.T., Kendrick, D., & Coleman, T. (2005). Non-legislative interventions for the promotion of cycle helmet wearing by children. *The Cochrane Database of Systematic Reviews.* Issue 2. Art No: CD003985, DOI: 10. 1002/14651858. CD003985. pub2.

Rutter, D.R., Quine, L., & Albery, I.P. (1998). Perceptions of risk in motorcyclysts: Unrealistic optimism, relative realism and predictions of behaviour. *British Journal of Psychology*, 89, 681-696.

Sacks, J.J., Holmgreen, P., Smith, S.M., & Sosin, D.M., (1991). Bicycle-associated head injuries and deaths in the United States from 1984-1988: How many are preventable? *JAMA*, 266, 3016-3016.

Schulman, J., Sacks, J., & Provenzano, G. (2002). State level estimates of the incidence and economic burden of head injuries stemming from non-universal use of bicycle helmets. *Injury Prevention*, 8, 47-52.

Simpson, E.M., Moll, E.K., Kassam-Adams, N., Miller, G.J., & Winston, F.K. (2002). Barriers to booster seat use and strategies to increase their use, *Pediatrics,* 110, 729-736.

Singer J.D., & Willett, J.B. (2003). *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence.* Oxford, NY: Oxford U niversity Press.

Slater, M.D. (1996). Theory and methods in health audience segmentation. *Journal of Health Communication*, 1, 267-283.

Snider, J.G. & Osgood, C.E. (1962). *Semantic Differential Technique: A Sourcebook.* Chicago: Il, Aldine Publishing Company.

Thompson, N.J., Sleet, D. & Sacks, J.J. (2002). Increasing the use of bicycle helmets: Lessons from behavioral science. *Patient Education and Counseling*, 46, 191-197.

Thompson, D.C., Rivara, F.P., & Thompson, R.S. (1996). Effectiveness of bicycle safety helmets in preventing head injuries: A case-control study. *JAMA*, 276, 1968-1973.

Trifiletti, L.B., Gielen, A.C., Sleet, D.A., & Hopkins, K. (2005). Behavioral and social sciences theories and models: Are they used in unintentional injury prevention research? *Health Education Research*, 20, 298-307.

U.S. Department of Health and Human Services (HHS). (2000). *Tracking Healthy People 2010.* Washington, DC: U.S. Government Printing Office. Retrieved May 28, 2007 from http://www.healthypeople.gov./document/tableofcontents. htm#tracking.

Wasserman, R.C., Waller, J.A., Monty, M.J., Emery, A.B., & Robinson, D.R. (1988). Bicyclists, helmets and head injuries: A rider-based study of helmet use and effectiveness. *American Journal of Public Health,* 78, 1220-1221.

Weinstein, N.D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology,* 39, 806-820.

Weinstein, N.D., Grubb, P.D., & Vautier, J.S. (1986). Increasing automobile seat belt use: An intervention emphasizing risk susceptibility. *Journal of Applied Psychology*, 71, 285-290.

Weiss, B.D. (1996). Helmet use among university bicyclists. *Journal of American College Health,* 44, 298-300.

Weiss, J., Okun, M., & Quay, N. (2004). Predicting bicycle helmet stage-of change among middle school, high school, and college cyclists from demographic, cognitive, and motivational variables. *Journal of Pediatrics,* 145, 360-364.

West, R. (2005). Time for a change: Putting the Transtheoretical (Stages of Change) Model to rest. *Addiction*, 100, 1036-1039.

Will, K.E. (2006). Child passenger safety and the immunity fallacy: Why what we are doing is not working. *Accident Analysis and Prevention*, 37, 947-955.

Witte, K., & Allen, M. (2000). A meta-analysis of fear appeals: Implications for effective public health campaigns. *Health Education & Behavior*, 27, 591-615.

Wittenbraker, J., Gibbs, B.L., & Kahle, L.R. (1983). Seat belt attitudes, habits, and behaviors: An adaptive amendment to the Fishbein model. *Journal of Applied social psychology,* 13, 406-421.

Ytterstad, B. (2003). The Harstad Injury Prevention Study: A decade of community based traffic injury prevention with emphasis on children. *International Journal of Curcumpolar Health,* 62,61-74.

Appendices

Appendix A. Cover letter

Colorado State University

Department of Psychology
1876 Campus Delivery
Fort Collins, Colorado 80523-1876
(970) 491-6363
FAX: (970) 491-1032
www.colostate.edu/Depts/Psychology/

Dear study participant,

My name is Itsumi Kakefuda, and I am a graduate student at Department of Psychology and a research assistant for Colorado Injury Control Research Center at CSU. I am beginning a study on bicycle safety among CSU students, and invite you to participate in the study. You are asked to take part because you have ridden a bicycle during the past month.

As part of the study, I am interested in your behaviors, past experiences, and opinions about bicycle safety. We hope that the information I collect will help us to better understand associations between attitudes, experiences, and bicycle safety behaviors.

You will be asked to complete the questionnaire after reading the cover letter. First, read instructions for answering questions which will be presented on the first page of the questionnaire. Then, answer the questions. Please read directions carefully and follow them. It should take approximately 5 minutes to complete.

This study is anonymous. That means that no one will know that the information you give comes from you. There are no known risks to participating in the study. It is not possible to identify all potential risks in research procedures, but we (researchers) have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

You may not receive any direct benefit from taking part in this study, but the study may help to increase knowledge that may help develop bicycle-related head injury prevention interventions in the future. You may choose to withdraw at any time without penalty.

<u>Please keep a copy of this letter for your records.</u> Before you start answering questions, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, Itsumi Kakefuda at 970-491-4329 or via e-mail at kakefuda@lamar. colostate.edu. If you have any questions about your rights as a volunteer in this research, contact Janell Meldrem, Human Research Administrator at 970-491-1655.

Your participation in this study will be greatly appreciated.

Sincerely,

I. Kakefuda

Itsumi Kakefuda, M.S. (Co-principal investigator)

Lorann Stallones

Lorann Stallones, MPH, Ph.D. (Principal investigator)

Colorado Injury Control Research Center
Department of Psychology
Colorado State University

Appendix B. Debriefing statement

Colorado State University

Knowledge to Go Places

Colorado Injury Control Research Center
Colorado State University
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College of Natural Sciences
Fort Collins, Colorado 80523-1876
(970) 491-0670
FAX: (970) 491-1032
http://psy.psych.colostate.edu/CICRC/

A debriefing statement

Thank you for your participation in the study formally titled "Identifying factors associated with different bicycle helmet use behaviors among college students."

A purpose of the study
The study is designed to understand associations between bicycle helmet use behaviors, attitudes toward bicycle helmet use, and past experiences of bicycle helmet use and of bicycle-related injuries. At recruitment, we described the study as 'a study to examine bicycle use and attitudes toward bicycle safety." We did not tell you that the study was about bicycle helmet use because we wanted to invite participants with different bicycle helmet use behaviors including consistent bicycle helmet users and non-users. If we had described the study such as 'bicycle helmet use survey' in the invitation, this might confuse some students and reduce number of participants who did not wear bicycle helmets.

A procedure of the study and data analysis
The study uses a printed questionnaire with items which have been suggested to be associated with bicycle helmet use in literature of bicycle helmet research and other traffic safety research. These are: purposes of bicycle riding (for commuting or for recreation); frequency of bicycle riding; attitudes toward bicycle helmet use; perceptions toward bicycle riding skills and risk of being involved in a bicycle-related incident; injury experiences in the past; norms of others including family and friends; and, demographic characteristics.

After collecting data, we will analyze data and examine which aspects listed above are associated with bicycle helmet use behaviors. This will provide us information to improve prevention programs to be designed to increase bicycle helmet use among college students.

If you are interested in injury prevention and safety promotion research, feel free to contact us.

Itsumi Kakefuda, M.S. (Co-principal investigator)

Lorann Stallones, MPH, Ph.D. (Principal investigator)

Colorado Injury Control Research Center

Appendix C. Questionnaire

Instructions for answering questions

Choose and mark an appropriate answer when there are response options such as "Never," "Sometimes," or "Every time" or "Yes" or "No,"

Example Every time Sometimes Never

or Yes No

Choose and mark an appropriate place on a response scale like below.

Example Strongly disagree |___|___|___|___|___|_✓_| Strongly agree

or Never |___|___|___|_X_|___|___| Always

Fill in a blank for a question like below.

Example What is your major? ____Psychology____

-- Demographics --

1. What is your age in years? ____________________

2. What is your gender?

Female Male

3. Are you a U.S. domestic student or international student?

Domestic student International student

4. What is your race and ethnicity if you are a domestic student, or what is your nationality if you are an international student?

4a. Race (if you are a domestic student)

|___| White American
|___| Black or African American
|___| American Indian or Alaska Native
|___| Asian American
|___| Other

4b. Ethnicity (if you are a domestic student)

|___| Spanish/Hispanic/Latino
|___| Not Spanish/Hispanic/Latino

4c. Nationality (if you are an international student) ________________________

5. How long have you lived in Fort Collins or surrounding area?

____

-- Frequency of bicycle ride by bicycle ride purposes --

6a. Do you ride a bicycle **to school (class)**?

Yes No

6b. **If yes to 6a**, how long does it take you to get school on a bicycle from the place you live?

____________ minutes

6c. **If yes to 6a**, how far is the place you live from school?

____________ miles

6d. **If yes to 6a**, how many days a week do you usually ride a bicycle **to school**?

Less than once a week	1 day a week	2 days a week	3 days a week	4 days a week	5 days a week	More than 5 days a week

7a. Do you ride a bicycle **for recreation** (e.g., riding on trails or in the mountains)?

Yes No

7b. **If yes to 7a**, how often do you ride a bicycle **for recreation**?

One or two times a year	One or two times a semester	About once a month	Almost every weekend	Weekends and some weekdays

8. Are you a member of a cycling club?

Yes No

-- Your opinions about bicycle helmet use --

Please mark appropriate place on the scale on ***every scale****.*
Example Convenient |___|_X_|___|___|___|___| Inconvenient

9. Wearing a bicycle helmet when riding **to school** is…

9a.	Foolish	|___|___|___|___|___|___|	Smart
9b.	Effective	|___|___|___|___|___|___|	Ineffective
9c.	Beneficial	|___|___|___|___|___|___|	Harmful
9d.	Uncomfortable	|___|___|___|___|___|___|	Comfortable
9e.	Necessary	|___|___|___|___|___|___|	Unnecessary
9f.	Good	|___|___|___|___|___|___|	Bad

10. Wearing a bicycle helmet when riding **for recreation** is…

10a.	Uncomfortable	|___|___|___|___|___|___|	Comfortable
10b.	Necessary	|___|___|___|___|___|___|	Unnecessary
10c.	Beneficial	|___|___|___|___|___|___|	Harmful
10d.	Foolish	|___|___|___|___|___|___|	Smart
10e.	Effective	|___|___|___|___|___|___|	Ineffective
10f.	Good	|___|___|___|___|___|___|	Bad

11. Increasing bicycle helmet use among CSU students is…

11a.	Necessary	|___|___|___|___|___|___|	Unnecessary
11b.	Foolish	|___|___|___|___|___|___|	Smart
11c.	Beneficial	|___|___|___|___|___|___|	Harmful
11d.	Good	|___|___|___|___|___|___|	Bad
11e.	Effective	|___|___|___|___|___|___|	Ineffective
11f.	Uncomfortable	|___|___|___|___|___|___|	Comfortable

12. Regulating bicycle helmet use on the CSU campus is…

12a. Beneficial |___|___|___|___|___|___| Harmful

12b. Effective |___|___|___|___|___|___| Ineffective

12c. Uncomfortable |___|___|___|___|___|___| Comfortable

12d. Foolish |___|___|___|___|___|___| Smart

12e. Necessary |___|___|___|___|___|___| Unnecessary

12f. Good |___|___|___|___|___|___| Bad

13. A bicycle helmet is expensive.

Strongly disagree |___|___|___|___|___|___| Strongly agree

14. A bicycle helmet will mess up my hair.

Strongly disagree |___|___|___|___|___|___| Strongly agree

15. Carrying a bicycle helmet around is cumbersome.

Strongly disagree |___|___|___|___|___|___| Strongly agree

16. A bicycle helmet can prevent serious head injury if I have a bicycle accident

Strongly disagree |___|___|___|___|___|___| Strongly agree

-- Bicycle riding skills --

17. Compared to other men/women my age, my competence on the road **as a safe bicycle rider** is…

Much below average |___|___|___|___|___|___| Much above average

18. Compared to other men/women my age, my competence on the road **as a skilled bicycle rider** is…

Much below average |___|___|___|___|___|___| Much above average

-- Bicycle-related injuries --

19. Compared to other men/women my age, my chance of getting a bicycle-related head injury is…

Much below average |___|___|___|___|___|___| Much above average

20. If I were involved in a bicycle-related head injury event, the injury would be…

Not at all serious |___|___|___|___|___|___| Extremely serious

21a. Have you been injured in a bicycle-related incident, which required you to visit emergency department or to be hospitalized?

Yes No

21b. **If yes to 21a**, which part(s) of the body did you got injured? *(Mark all apply)*

Head Face Upper body other than head

Lower body

21c. **If yes to 21a**, which treatment did you receive?

Hospitalized Emergency department visit

22a. Has anyone around you been injured, which required them to visit emergency department or to be hospitalized, or killed in a bicycle-related incident?

Yes No

22b. **If yes to 22**, which part(s) of the body did they got injured? *(Mark all apply)*

Head Face Upper body other than head

Lower body I don't know

-- Bicycle helmet use and intention --

23a. In the past 30 days, when you rode bicycle **to school** (class), how often did you wear a helmet?

Every time Almost every time Sometimes Almost never Never

(If you answered "**Every time**" to Question **23a**)

23aa. How long has it been since you started wearing a helmet every time you ride a bicycle **to school**?

Number of years ____________

(If you answered **anything other than "Every time"** to Question **23a**)

23ab. Are you considering starting to wear a helmet every time you ride **to school** within the next 6 months?

Yes No

24a. In the past 6 months, when you rode a bicycle **for recreation**, how often did you wear a helmet?

Every time Almost every time Sometimes Almost never Never

(If you answered "**Every time**" to Question **24a**)

24aa. How long has it been since you started wearing a helmet every time you ride a bicycle **for recreation**?

Number of years ____________

(If you answered **anything other than "Every time"** to Question **24a**)

24ab. Are you considering starting to wear a helmet every time you ride **for recreation** within the next 6 months?

Yes No

25. Do you own a bicycle helmet?

Yes No

26. How often did you wear a bicycle helmet during… (N/A: No bicycle riding)

26a. Elementary school	Never	|___|___|___|___|___|___|	Always	N/A
26b. Junior high school	Never	|___|___|___|___|___|___|	Always	N/A
26c. High school	Never	|___|___|___|___|___|___|	Always	N/A

27a. Have you ever lived in a community which has a law requiring residents to wear bicycle helmets?

Yes No

27b. **If yes to 27a,** did the law apply to you when you were living in the community?

Yes No

For questions 28-38, please mark appropriate place on the scale on every scale.

Example I should not |___|_X_|___|___|___|___| I should

28. My close friends think…

I should not |___|___|___|___|___|___| I should

wear a bicycle helmet every time while riding a bicycle.

29. My family members think…

I should not |___|___|___|___|___|___| I should

wear a bicycle helmet every time while riding a bicycle.

30. In Fort Collins,

I should not |___|___|___|___|___|___| I should

wear a bicycle helmet every time while riding a bicycle.

31. I would be more likely to wear a helmet if my doctor told me it was important.

Strongly disagree |___|___|___|___|___|___| Strongly agree

32. Wearing a bicycle helmet gives me peace of mind about my safety.

Strongly disagree |___|___|___|___|___|___| Strongly agree

33. I wear a bicycle helmet even when my friends make fun of me.

Strongly disagree |___|___|___|___|___|___| Strongly agree

34. If I am careful and obey rules when I ride my bicycle I do not need to wear a helmet.

Strongly disagree |___|___|___|___|___|___| Strongly agree

35. Wearing a bicycle helmet is uncomfortable.

Strongly disagree |___|___|___|___|___|___| Strongly agree

36. I would probably not wear a helmet unless I had an accident and hit my head.

Strongly disagree |___|___|___|___|___|___| Strongly agree

37. When riding around home or short distances, I do not need to wear a bicycle helmet.

Strongly disagree |___|___|___|___|___|___| Strongly agree

38. People who are close to me benefit if I wear a bicycle helmet.

Strongly disagree |___|___|___|___|___|___| Strongly agree

The end of the questionnaire.
Thank you for your participation!

Appendix D. Univariate correlations among study variables

Abbreviations of variable names

Stage Com, Stage Rec: Stages of Change for commuting and for recreation
Race: Race/Ethnicity
Native FC: Fort Collins native
Bike Club: Bicycle club membership
Past Law: Having lived a place where bicycle helmet use was required
Injury Self: Injury experiences of respondents
Injury Other: Injury experiences of people whom respondents knew
Live Years: Years of living in Fort Collins
Com Freq, Rec Freq: Bicycle use frequency for commuting and for recreation
Com Min: Minutes of commuting
Past Elm, Past JH, Past Hi: Bicycle helmet use in elementary, junior high school, and high school
Com Good: Bicycle helmet use for commuting is Bad-Good
Com Smrt: Bicycle helmet use for commuting is Foolish-Smart
Com Comf: Bicycle helmet use for commuting is Uncomfortable-Comfortable
Com Effc: Bicycle helmet use for commuting is Ineffective-Effective
Com Benef: Bicycle helmet use for commuting is Harmful-Beneficial
Com Nec: Bicycle helmet use for commuting is Unnecessary-Necessary
Rec Good: Bicycle helmet use for recreation is Bad-Good
Rec Smrt: Bicycle helmet use for recreation is Foolish-Smart
Rec Comf: Bicycle helmet use for recreation is Uncomfortable-Comfortable
Rec Effc: Bicycle helmet use for recreation is Ineffective-Effective
Rec Benef: Bicycle helmet use for recreation is Harmful-Beneficial
Rec Necs: Bicycle helmet use for recreation is Unnecessary-Necessary
CSU Good: Increasing bicycle helmet use among CSU students is Bad-Good
CSU Smrt: Increasing bicycle helmet use among CSU students is Foolish-Smart
CSU Comf: Increasing bicycle helmet use among CSU students is Uncomfortable-Comfortable
CSU Effc: Increasing bicycle helmet use among CSU students is Ineffective-Effective
CSU Benef: Increasing bicycle helmet use among CSU students is Harmful-Beneficial
CSU Necs: Increasing bicycle helmet use among CSU students is Unnecessary-Necessary
Reg Good: Bicycle helmet regulation on CSU campus is Bad-Good
Reg Smrt: Bicycle helmet regulation on CSU campus is Foolish-Smart
Reg Comf: Bicycle helmet regulation on CSU campus is Uncomfortable-Comfortable
Reg Effc: Bicycle helmet regulation on CSU campus is Ineffective-Effective
Reg Benef: Bicycle helmet regulation on CSU campus is Harmful-Beneficial
Reg Necs: Bicycle helmet regulation on CSU campus is Unnecessary-Necessary
Cost: A bicycle helmet is expensive
Hair: A bicycle helmet will mess up my hair
Cumb: Carrying around helmet around is cumbersome
Prevention: A bicycle helmet can prevent serious head injury
Doctor: I would wear a helmet if my doctor told me it was important
Peace: Wearing a helmet gives me peace of mind
Ridiculed: I wear a helmet even when my friends make fun of me
Careful: No need if I am careful and obey rules
Uncomf: Wearing a helmet is uncomfortable
Head: I would not wear a helmet unless I hit my head
Distance: No need for short distance ride
Benefit: People who are close to me benefit if I wear a bicycle helmet
Nm Friend, Nm Fam, Nm FC: Perceived norms of friends, family, and Fort Collins
Safer: Perceived control on the road as a safe bicycle rider
Skilled: Perceived control on the road as a skilled bicycle rider
Probable: Probability of getting a bicycle-related head injury
Severe: Severity of bicycle-related head injury

Table descriptions

The first two rows of Tables D-1 to D-6 presented p-values from non-parametric tests for associations between Stages of Change and all study variables.

The upper diagonal half of Tables D-1 to D-6 presented p-values from non-parametric tests for associations among study variables when they were significant.

The lower diagonal half of Table D-1 presented mean values of interval and ordinal variables for each category of categorical variables: Gender, Race, Native FC, Bike Club, Past Law, Injury Self, and Injury Other, when differences were significant.

The lower diagonal half of Tables D-2 to D-6 presented Kendall tau correlation coefficients for associations among interval and ordinal variables, when they were significant.

Table D-1

	Gender	Race	Native FC	Bike Club	Past Law	Injury Self	Injury Other
Stage Com	0.0718	0.8364	0.4915	0.9496	0.9057	0.5797	0.0006
Stage Rec	0.3237	0.5544	0.4804	0.0095	0.5841	0.4775	0.0002
Gender							
Race						0.0035	
Native FC							
Bike Club							
Past Law							
Injury Self							0.0061
Injury Other							
Age	21.67/23.82	22.13/24.5/31.13	20.65/23.05	19.00/22.85			
Live Years			5.89/3.51				
Rec Freq	3.16/3.74			4.60/3.42			
Com Freq	4.27/5.15		4.14/4.81				
Com Min						12.00/9.78	
Past Elm	4.47/3.66	4.33/3.10/1.00		6.00/4.01			
Past JH		3.40/2.10/1.00	4.11/3.01	4.83/3.12			3.45/2.88
Past Hi		2.88/1.89/1.00	3.67/2.54				3.28/2.10
Com Good	5.34/5.07						5.39/5.01
Com Smrt							
Com Comf							3.05/2.54
Com Effc							4.99/4.53
Com Benef							5.34/5.08
Com Nec	4.23/3.64	3.84/4.24/5.13					4.18/3.66
Rec Good							5.74/5.44
Rec Smrt							5.69/5.37
Rec Comf							3.95/3.35
Rec Effc							5.61/5.33
Rec Benef							5.74/5.41
Rec Necs							5.51/5.15
CSU Good							5.23/4.96
CSU Smrt		4.65/5.24/5.38					
CSU Comf							3.73/3.22
CSU Effc							4.63/4.21
CSU Benef							5.26/4.91
CSU Necs		4.20/4.67/5.13					4.55/4.01
Reg Good	4.09/3.33						
Reg Smrt	3.60/3.07						
Reg Comf							2.82/2.42
Reg Effc	3.40/2.77	2.95/3.71/4.25					
Reg Benef					2.97/3.73		
Reg Necs	3.45/2.85	3.00/4.10/3.88					
Cost							
Hair	2.87/3.53						
Cumb			3.00/2.45				
Prevention							5.60/5.24
Doctor		3.44/3.24/5.13					
Peace							4.41/3.69
Ridiculed				5.33/3.61			4.04/3.25
Careful	4.05/3.33			5.33/3.64			
Uncomf				4.50/2.90			
Head				5.33/3.71			4.19/3.31
Distance							3.22/2.61
Benefit							4.56/3.95
Nm Friend							4.16/3.55
Nm Fam							5.45/5.03
Nm FC							4.65/4.15
Safer	2.76/2.28			1.17/2.56			2.37/2.68
Skilled	3.01/2.25			1.33/2.66		2.27/2.69	
Probable				4.50/3.40		4.18/3.29	3.62/3.24
Severe							4.12/3.67

Mean values are shown in the order as follows.
Gender: Female/Male. Race: Non-Hispanic white/Other race or ethnicity/International student.
Native FC: Yes/No. Bike Club: Yes/No. Past Law: Yes/No. Injury Self: Yes/No. Injury Other: Yes/No

Table D-2

	Age	Live Years	Rec Freq	Com Freq	Com Min	Past Elm	Past JH	Past Hi
Stage Com	0.0376	*0.8190*	*0.4326*	*0.6051*	0.0137	*0.8668*	*0.1289*	0.0092
Stage Rec	*0.7341*	*0.7988*	*0.1466*	*0.2990*	*0.4845*	*0.1485*	0.0003	<0.0001
Gender	0.0031		0.0007	0.0003		0.0046		
Race	<0.0001					<0.0001	0.0002	0.0021
Native FC	0.0246	<0.0001		0.0255			0.0064	0.0069
Bike Club	0.0038		0.0259			0.0093	0.0396	
Past Law								
Injury Self					0.0295			
Injury Other							0.0435	0.0002
Age		<0.0001			<0.0001	<0.0001	<0.0001	0.0022
Live Years	0.23			0.0387	0.0066			
Rec Freq				<0.0001				0.0374
Com Freq		-0.12	0.32		0.0125			
Com Min	0.25	0.15		-0.14				
Past Elm	-0.44						<0.0001	<0.0001
Past JH	-0.35					0.67		<0.0001
Past Hi	-0.18		0.13			0.41	0.64	
Com Good								0.15
Com Smrt	0.14				0.15			0.17
Com Comf			0.13		0.13			0.21
Com Effc			0.13		0.12			
Com Benef								0.14
Com Nec								0.15
Rec Good								0.21
Rec Smrt								0.24
Rec Comf							0.18	0.25
Rec Effc			0.14			0.16	0.17	0.23
Rec Benef							0.14	0.23
Rec Necs							0.14	0.21
CSU Good								0.17
CSU Smrt			0.35					0.19
CSU Comf			0.27				0.14	0.24
CSU Effc			0.19					
CSU Benef			0.34					0.14
CSU Necs			0.23				0.15	0.19
Reg Good	-0.13			-0.18			0.15	0.13
Reg Smrt			0.13				0.15	
Reg Comf						0.13	0.19	0.23
Reg Effc		-0.12						
Reg Benef								
Reg Necs				-0.11			0.14	
Cost					0.13			
Hair								0.16
Cumb							0.13	
Prevention			0.17					
Doctor				-0.18				
Peace							0.19	0.27
Ridiculed			0.12				0.14	0.27
Careful							0.15	0.19
Uncomf			0.13				0.18	0.28
Head		0.12	0.19				0.18	0.29
Distance								0.13
Benefit			0.17				0.14	0.23
Nm Friend	0.12							0.17
Nm Fam		-0.14	0.13			0.19	0.25	0.29
Nm FC			0.12				0.16	0.17
Safer			-0.34	-0.21				-0.13
Skilled			-0.28	-0.25				-0.14
Probable			0.15	0.16				
Severe				0.19				

Table D-3

	Com Good	Com Smrt	Com Comf	Com Effc	Com Bene	Com Nec	Rec Good	Rec Smrt	Rec Comf	Rec Effc	Rec Bene	Rec Necs
Stage Com	0.0005	<0.0001	<0.0001	0.0007	0.0524	<0.0001	0.1178	0.0032	0.0016	0.2017	0.1372	0.0035
Stage Rec	0.0545	0.0504	<0.0001	0.2313	0.4524	0.0789	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Gender	0.0107					0.0068						
Race						0.0306						
Native FC												
Bike Club												
Past Law												
Injury Self												
Injury Other	0.0027		0.0198	0.0041	0.0284	0.0158	0.0039	0.0018	0.0131	0.0025	0.0008	0.0046
Age		0.0189										
Live Years												
Rec Freq			0.0282	0.0304						0.0301		
Com Freq												
Com Min		0.0094	0.0199	0.0436								
Past Elm										0.0163		
Past JH									0.0023	0.0075	0.0300	0.0328
Past Hi	0.018	0.0061	0.0006		0.0258	0.0104	0.0012	0.0002	<0.0001	0.0004	0.0005	0.0011
Com Good		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0032	<0.0001	<0.0001	<0.0001
Com Smrt	0.41		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0026	<0.0001	<0.0001	<0.0001
Com Comf	0.23	0.27		<0.0001	0.0009	<0.0001	0.0282	0.0004	<0.0001	0.0087	0.0078	<0.0001
Com Effc	0.45	0.45	0.24		<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Com Benef	0.48	0.43	0.20	0.63		<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
Com Nec	0.45	0.42	0.37	0.37	0.32		<0.0001	0.0229	0.0013	0.0017	0.0027	<0.0001
Rec Good	0.49	0.31	0.14	0.37	0.41	0.26		<0.0001	0.0003	<0.0001	<0.0001	<0.0001
Rec Smrt	0.32	0.42	0.22	0.30	0.39	0.14	0.62		<0.0001	<0.0001	<0.0001	<0.0001
Rec Comf	0.18	0.18	0.57			0.18	0.22	0.29		0.0001	<0.0001	<0.0001
Rec Effc	0.38	0.30	0.16	0.40	0.41	0.19	0.71	0.61	0.24		<0.0001	<0.0001
Rec Benef	0.40	0.33	0.17	0.32	0.47	0.19	0.64	0.59	0.29	0.73		<0.0001
Rec Necs	0.29	0.28	0.25	0.25	0.29	0.25	0.60	0.56	0.36	0.60	0.67	
CSU Good	0.44	0.34	0.18	0.36	0.43	0.40	0.41	0.32		0.34	0.34	0.22
CSU Smrt	0.37	0.47	0.23	0.42	0.37	0.43	0.35	0.35	0.17	0.39	0.33	0.21
CSU Comf	0.23	0.26	0.46	0.23	0.24	0.29	0.24	0.27	0.48	0.21	0.21	0.24
CSU Effc	0.37	0.21	0.23	0.31	0.29	0.41	0.26	0.19		0.29	0.23	
CSU Benef	0.39	0.35	0.17	0.39	0.44	0.40	0.37	0.34		0.34	0.35	0.23
CSU Necs	0.39	0.33	0.24	0.35	0.34	0.55	0.36	0.23	0.15	0.30	0.28	0.23
Reg Good	0.37	0.22	0.21	0.23	0.21	0.44	0.24		0.14	0.16	0.15	
Reg Smrt	0.30	0.27	0.31	0.27	0.24	0.43	0.17	0.13	0.19	0.13		0.14
Reg Comf	0.17	0.19	0.44	0.17	0.16	0.36			0.33			0.15
Reg Effc	0.28	0.19	0.29	0.21	0.20	0.39	0.13					
Reg Benef	0.33	0.18	0.22	0.19	0.14	0.39	0.17		0.14	0.14		0.13
Reg Necs	0.32	0.20	0.23	0.25	0.19	0.47	0.14			0.13		
Cost		0.14										0.13
Hair			0.24						0.16			
Cumb	0.13		0.33			0.20			0.22			0.14
Prevention	0.22	0.21	0.15	0.23	0.20	0.24	0.21	0.29		0.31	0.29	0.28
Doctor	0.15		0.12	0.17		0.26						
Peace	0.30	0.22	0.24	0.20	0.21	0.35	0.30	0.31	0.23	0.23	0.25	0.32
Ridiculed	0.15	0.21	0.26		0.14	0.21	0.21	0.28	0.26	0.19	0.22	0.22
Careful	0.16	0.22	0.23			0.33	0.16	0.16	0.25		0.18	0.23
Uncomf	0.16	0.16	0.49			0.16	0.19	0.26	0.52	0.15	0.17	0.32
Head	0.13	0.22	0.31	0.12		0.22	0.15	0.31	0.23	0.17	0.16	0.28
Distance	0.32	0.31	0.33	0.21	0.23	0.38	0.17	0.19	0.21			0.17
Benefit	0.32	0.27	0.16	0.22	0.29	0.34	0.27	0.22	0.16	0.23	0.21	0.20
Nm Friend	0.26	0.22	0.28	0.19	0.20	0.32		0.23	0.24	0.14	0.14	0.19
Nm Fam	0.32	0.21	0.21	0.18	0.22	0.30	0.30	0.33	0.24	0.29	0.32	0.29
Nm FC	0.35	0.31	0.32	0.26	0.26	0.51	0.18	0.20	0.22	0.20	0.19	0.21
Safer				-0.16						-0.15		
Skilled					-0.14				-0.12	-0.13		
Probable		0.12										
Severe								0.18	0.14		0.14	

Table D-4

	CSU Good	CSU Smrt	CSU Comf	CSU Effc	CSU Bene	CSU Necs	Reg Good	Reg Smrt	Reg Comf	Reg Effc	Reg Bene	Reg Necs
Stage Com	<0.0001	<0.0001	0.0039	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0003	<0.0001	0.0008	0.0004
Stage Rec	0.0387	0.0077	0.0004	0.2052	0.0303	0.0016	*0.3557*	0.0218	<0.0001	*0.3974*	*0.1204*	*0.5675*
Gender							0.0027	0.0339		0.0103		0.0175
Race		0.0303				0.0362				0.0315		0.0276
Native FC												
Bike Club												
Past Law											0.0269	
Injury Self												
Injury Other	0.0136		0.0084	0.0367	0.0091	0.0155			0.0443			
Age							0.0214					
Live Years										0.0344		
Rec Freq		<0.0001	<0.0001	0.0031	<0.0001	0.0002		0.0293				
Com Freq							0.0012					0.043
Com Min												
Past Elm									0.0315			
Past JH			0.0168			0.0113	0.0131	0.0110	0.0012			0.0200
Past Hi	0.0082	0.0027	<0.0001		0.0319	0.0021	0.0346		0.0001			
Com Good	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0045	<0.0001	<0.0001	<0.0001
Com Smrt	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001	0.0002	<0.0001	0.0012	0.0014	0.0032	0.0009
Com Comf	0.0032	<0.0001	<0.0001	<0.0001	0.0041	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Com Effc	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0032	0.0004	0.0013	<0.0001
Com Benef	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	0.0102	0.0009	0.0218	0.0015
Com Nec	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Rec Good	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0076		0.0419	0.0070	0.2226
Rec Smrt	<0.0001	<0.0001	<0.0001	0.0031	<0.0001	0.0002		0.0293				
Rec Comf		0.0040	<0.0001			0.0067	0.0164	0.0007	<0.0001		0.0107	
Rec Effc	<0.0001	<0.0001	0.0006	<0.0001	<0.0001	<0.0001	0.0096	0.0280			0.0270	0.0381
Rec Benef	<0.0001	<0.0001	0.0008	0.0003	<0.0001	<0.0001	0.0161					
Rec Necs	0.0007	0.0008	0.0001		0.0004	0.0001		0.0174	0.0137		0.0286	
CSU Good		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
CSU Smrt	0.71		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
CSU Comf	0.32	0.41		<0.0001	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	0.0005	<0.0001	<0.0001
CSU Effc	0.56	0.52	0.29		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
CSU Benef	0.83	0.72	0.32	0.55		<0.0001	<0.0001	<0.0001	0.0009	<0.0001	<0.0001	<0.0001
CSU Necs	0.61	0.61	0.39	0.61	0.64		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Reg Good	0.42	0.42	0.21	0.42	0.41	0.47		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Reg Smrt	0.35	0.40	0.32	0.41	0.36	0.50	0.67		<0.0001	<0.0001	<0.0001	<0.0001
Reg Comf	0.23	0.29	0.51	0.27	0.20	0.31	0.40	0.51		<0.0001	<0.0001	<0.0001
Reg Effc	0.26	0.29	0.20	0.39	0.29	0.43	0.60	0.68	0.39		<0.0001	<0.0001
Reg Benef	0.37	0.36	0.24	0.36	0.37	0.43	0.66	0.68	0.42	0.64		<0.0001
Reg Necs	0.33	0.39	0.25	0.42	0.35	0.53	0.70	0.72	0.45	0.64	0.65	
Cost		0.13	0.16			0.15						
Hair								0.12	0.18			
Cumb			0.23			0.16	0.13	0.19	0.22	0.12	0.16	0.14
Prevention	0.26	0.32	0.19	0.31	0.35	0.41	0.22	0.26		0.19	0.19	0.25
Doctor	0.19	0.20	0.18	0.28	0.20	0.29	0.28	0.24	0.18	0.19	0.20	0.29
Peace	0.35	0.28	0.31	0.26	0.36	0.37	0.31	0.27	0.24	0.23	0.24	0.24
Ridiculed	0.14	0.15	0.26		0.15	0.22	0.13	0.16	0.22			
Careful		0.16	0.13			0.21	0.14	0.17	0.15	0.14		0.13
Uncomf			0.34			0.12		0.17	0.29		0.12	
Head			0.21					0.14	0.19			
Distance	0.23	0.29	0.19	0.19	0.21	0.31	0.31	0.33	0.22	0.25	0.23	0.26
Benefit	0.32	0.31	0.2	0.28	0.32	0.39	0.28	0.26	0.14	0.19	0.21	0.23
Nm Friend	0.21	0.23	0.28	0.19	0.25	0.29	0.22	0.26	0.20	0.22	0.25	0.20
Nm Fam	0.30	0.28	0.23	0.22	0.33	0.32	0.26	0.22	0.19	0.16	0.20	0.23
Nm FC	0.30	0.37	0.32	0.31	0.32	0.47	0.37	0.42	0.34	0.35	0.32	0.41
Safer						-0.14						
Skilled												
Probable												
Severe						0.14						

Table D-5

	Cost	Hair	Cumb	Preventior	Doctor	Peace	Ridiculed	Careful	Uncomf	Head	Distance	Benefit
Stage Com	*0.1275*	*0.2885*	<0.0001	0.0021	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Stage Rec	*0.6834*	0.0210	0.0016	0.0052	0.1285	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	0.0050	0.0260
Gender		0.0082						0.0035				
Race					0.0109							
Native FC			0.0314									
Bike Club							0.0172	0.0124	0.0167	0.0205		
Past Law												
Injury Self												
Injury Other				0.0028		0.0005	0.0014			0.0002	0.0114	0.0081
Age												
Live Years										0.0334		
Rec Freq				0.0072			0.0404		0.0327	0.0010		0.0045
Com Freq					0.0017							
Com Min	0.0240											
Past Elm												
Past JH			0.0383			0.0018	0.0195	0.0146	0.0029	0.0021		0.0231
Past Hi		0.0062				<0.0001	<0.0001	0.0023	<0.0001	<0.0001	0.0293	0.0002
Com Good			0.0392	0.0009	0.0106	<0.0001	0.0123	0.009	0.0097	0.0264	<0.0001	<0.0001
Com Smrt	0.0208			0.0008		0.0002	0.0004	0.0002	0.0073	0.0002	<0.0001	<0.0001
Com Comf		<0.0001	<0.0001	0.0181	0.0425	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0053
Com Effc				0.0003	0.0028	0.0005				0.0368	0.0005	0.0002
Com Benef				0.0023		0.0004	0.0218				0.0002	<0.0001
Com Nec			0.0005	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0060	0.0001	<0.0001	<0.0001
Rec Good				0.0016		<0.0001	0.0009	0.0103	0.0022	0.0133	0.0077	<0.0001
Rec Smrt				<0.0001		<0.0001	<0.0001	0.011	<0.0001	<0.0001	0.0024	0.0004
Rec Comf		0.0041	0.0001			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0055
Rec Effc				<0.0001		0.0002	0.0023		0.0129	0.0071		0.0002
Rec Benef				<0.0001		<0.0001	0.0003	0.0054	0.0063	0.0112		0.0008
Rec Necs	0.0283		0.0202	<0.0001		<0.0001	0.0004	0.0002	<0.0001	<0.0001	0.0046	0.0012
CSU Good				<0.0001	0.0018	<0.0001	0.0173				0.0002	<0.0001
CSU Smrt	0.0245			<0.0001	0.0007	<0.0001	0.0117	0.0066			<0.0001	<0.0001
CSU Comf	0.0047		<0.0001	0.0023	0.0019	<0.0001	<0.0001	0.0249	<0.0001	0.0003	0.0008	0.0005
CSU Effc				<0.0001	<0.0001	<0.0001					0.0014	<0.0001
CSU Benef				<0.0001	0.0009	<0.0001	0.0133				0.0006	<0.0001
CSU Necs	0.0114		0.0069	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.0426		<0.0001	<0.0001
Reg Good			0.0195	0.0003	<0.0001	<0.0001	0.0257	0.0157			<0.0001	<0.0001
Reg Smrt		0.0321	0.0009	<0.0001	<0.0001	<0.0001	0.0053	0.0028	0.0030	0.0127	<0.0001	<0.0001
Reg Comf		0.0014	0.0002		0.0014	<0.0001	0.0001	0.0123	<0.0001	0.0011	0.0002	0.0164
Reg Effc			0.0338	0.0016	0.0009	<0.0001		0.0156			<0.0001	0.0013
Reg Benef			0.0058	0.0018	0.0006	<0.0001			0.0428		<0.0001	0.0003
Reg Necs			0.0197	<0.0001	<0.0001	<0.0001		0.0268			<0.0001	<0.0001
Cost		0.0287	0.0403						0.0007	0.0267	0.0203	
Hair	0.12		<0.0001						<0.0001	0.0085	0.0007	
Cumb	0.12	0.34				0.002	0.0033		<0.0001	<0.0001	<0.0001	0.0367
Prevention					0.0432	0.0002					0.0212	0.0003
Doctor				0.12		<0.0001	0.0014				0.0042	0.0010
Peace			0.18	0.23	0.39		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Ridiculed			0.17		0.18	0.43		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Careful						0.25	0.25		0.0002	<0.0001	<0.0001	0.0024
Uncomf	0.19	0.35	0.37			0.29	0.33	0.21		<0.0001	<0.0001	0.0006
Head	0.13	0.15	0.26			0.36	0.36	0.25	0.37		<0.0001	<0.0001
Distance	0.13	0.19	0.28	0.14	0.17	0.28	0.24	0.37	0.30	0.28		<0.0001
Benefit			0.12	0.22	0.19	0.43	0.31	0.18	0.20	0.24	0.27	
Nm Friend			0.17	0.21	0.22	0.31	0.23		0.21	0.22	0.29	0.27
Nm Fam				0.31	0.17	0.34	0.28	0.18	0.21	0.17	0.19	0.30
Nm FC			0.19	0.28	0.28	0.40	0.26	0.27	0.22	0.34	0.38	0.35
Safer				-0.15		-0.16	-0.15			-0.19		
Skilled		-0.14			0.14		-0.13		-0.16			
Probable		0.12			-0.13				0.12			
Severe				0.16		0.13					0.12	0.22

Table D-6

	Nm Friend	Nm Fam	Nm FC	Safer	Skilled	Probable	Severe
Stage Com	<0.0001	0.0002	<0.0001	0.0315	*0.2980*	*0.7502*	*0.4438*
Stage Rec	0.0012	<0.0001	0.0004	0.0158	0.0064	*0.1938*	*0.4342*
Gender				0.0001	<0.0001		
Race							
Native FC							
Bike Club				0.0011	0.0035	0.0276	
Past Law							
Injury Self					0.0311	0.0014	
Injury Other	0.0028	0.0058	0.0053	0.0325		0.0382	0.0154
Age	0.0305						
Live Years		0.0227					
Rec Freq		0.0378	0.0348	<0.0001	<0.0001	0.0133	
Com Freq				0.0002	<0.0001	0.0050	0.0013
Com Min							
Past Elm		0.0031					
Past JH		<0.0001	0.0079				
Past Hi	0.0056	<0.0001	0.0043	0.0425	0.0231		
Com Good	<0.0001	<0.0001	<0.0001				
Com Smrt	0.0004	0.0008	<0.0001			0.0426	
Com Comf	<0.0001	0.0006	<0.0001				
Com Effc	0.0017	0.0036	<0.0001	0.0072			
Com Benef	0.0011	0.0005	<0.0001		0.0262		
Com Nec	<0.0001	<0.0001	<0.0001				
Rec Good		<0.0001	0.0047				
Rec Smrt	0.0003	<0.0001	0.001				0.0041
Rec Comf	<0.0001	<0.0001	0.0001		0.0367		0.0132
Rec Effc	0.0259	<0.0001	0.0011	0.0219	0.0353		
Rec Benef	0.0315	<0.0001	0.0033				0.0241
Rec Necs	0.0015	<0.0001	0.0005				
CSU Good	0.0007	<0.0001	<0.0001				
CSU Smrt	0.0001	<0.0001	<0.0001				
CSU Comf	<0.0001	0.0002	<0.0001				
CSU Effc	0.0011	0.0004	<0.0001				
CSU Benef	<0.0001	<0.0001	<0.0001				
CSU Necs	<0.0001	<0.0001	<0.0001	0.0160			0.0150
Reg Good	0.0001	<0.0001	<0.0001				
Reg Smrt	<0.0001	0.0003	<0.0001				
Reg Comf	0.0007	0.0016	<0.0001				
Reg Effc	0.0001	0.0073	<0.0001				
Reg Benef	<0.0001	0.0009	<0.0001				
Reg Necs	0.0005	0.0001	<0.0001				
Cost							
Hair					0.0147	0.0402	
Cumb	0.0034		0.0009				
Prevention	0.0008	<0.0001	<0.0001	0.0196			0.0128
Doctor	0.0002	0.0048	<0.0001		0.0148	0.0207	
Peace	<0.0001	<0.0001	<0.0001	0.0053			0.0245
Ridiculed	<0.0001	<0.0001	<0.0001	0.0124	0.0283		
Careful		0.0031	<0.0001				
Uncomf	0.0002	0.0004	0.0002		0.0083	0.0354	
Head	0.0001	0.0056	<0.0001	0.0015			
Distance	<0.0001	0.0015	<0.0001				0.0402
Benefit	<0.0001	<0.0001	<0.0001				0.0002
Nm Friend		<0.001	<0.0001	0.0017			0.0191
Nm Fam	0.35		<0.0001	0.0181	0.0206		0.0058
Nm FC	0.41	0.42		0.0050			
Safer	-0.19	-0.15	-0.17		<0.0001		0.0032
Skilled		-0.14		0.55			0.0107
Probable							0.0001
Severe	0.14	0.17		-0.18	-0.15	0.22	

Appendix E

Proportional odds regression models with bicycle helmet use as outcome variables

The original bicycle helmet use scale with 5-point response options ('Never' - 'Every time') was transformed into a 3-point scale because the proportional odds assumption did not hold for the data with 5-point scale. The three categories include: never used, inconsistently used, and always used.

Multivariate Proportional Odds Regression Model for Bicycle Helmet Use for Commuting

Variable	Reference	Odds ratio	95%CI
Gender	Female	1.24	0.52-2.97
Age	Older	1.07	0.98-1.17
Minutes of commuting	Longer	1.07	1.00-1.14
Helmet use in high school	Frequent	1.13	0.88-1.46
Injury experiences of others	Yes	1.61	0.64-4.05
Helmet use for commuting	Positive	1.13	0.53-2.40
Helmet use for recreation	Positive	1.07	0.44-2.61
Increasing helmet use on CSU campus	Positive	1.56	0.81-3.03
Helmet regulation on CSU campus	Positive	0.89	0.63-1.27
Comfortable with helmet use and promotion efforts	Comfortable	1.34	0.87-2.08
Need of bicycle helmet use	High need	1.22	0.76-1.97
Emotional importance of helmet use	Important	**2.84**	**1.27-6.37**
Inconvenience of bicycle helmet use	Not inconvenient	1.29	0.82-2.03
Perceptions toward bicycle-related injury	High risk	0.86	0.46-1.62

Score test for the proportional odds assumption was not significant (χ^2[14]=14.81, p=0.39).
Pseudo R-Square: 0.43
Odds ratio presents odds of being at (a) lower stage(s) compared to the reference group or reference scale point.

Multivariate Proportional Odds Regression Model for Bicycle Helmet Use for Recreation

Variable	Reference	Odds ratio	95%CI
Helmet use in junior high school	Frequent	0.80	0.61-1.04
Helmet use in high school	Frequent	**1.68**	**1.25-2.27**
Injury experiences of others	Yes	0.79	0.37-1.67
Helmet use for commuting	Positive	**0.45**	**0.24-0.85**
Helmet use for recreation	Positive	**5.80**	**2.83-11.89**
Increasing helmet use on CSU campus	Positive	0.75	0.46-1.21
Comfortable with helmet use and promotion efforts	Comfortable	**1.53**	**1.06-2.21**
Need of bicycle helmet use	High need	1.09	0.71-1.67
Emotional importance of helmet use	Important	**2.36**	**1.23-4.52**
Inconvenience of bicycle helmet use	Not inconvenient	1.10	0.74-1.63
Perceptions toward bicycle-related injury	High risk	0.67	0.45-1.01
Perceptions toward control on the road	Low control	0.84	0.49-1.43

Score test for the proportional odds assumption was not significant (χ^2[12]=11.73, p=0.47).
Pseudo R-Square: 0.50
Odds ratio presents odds of being at (a) lower stage(s) compared to the reference group or reference scale point.