TECHNICAL REPORT Guidance for the Clinician in Rendering Pediatric Care

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

Helmet Use in Preventing Head Injuries in Bicycling, Snow Sports, and Other Recreational Activities and Sports

Lois K. Lee, MD, MPH, FAAP,[a] Michael R. Flaherty, DO,[b] Ashley M. Blanchard, MD, MSc, FAAP,[c] Maneesha Agarwal, MD, FAAP,[d] and THE COUNCIL ON INJURY, VIOLENCE, AND POISON PREVENTION

Bicycling, snow sports, and other recreational activities and sports are important activities to keep children and youth active as part of a healthy lifestyle. These activities can be associated with serious and fatal head and facial injuries. Helmets, when worn correctly, are effective in decreasing head injuries and fatalities related to these activities. Legislation for helmet use is effective in increasing helmet use in children and, ultimately, in decreasing deaths and head and facial injuries. A multipronged strategy employing legislation, enforcement of laws, and medical clinicians and community programs is important for increasing helmet use to decrease deaths and injuries from recreational sports.

Sport- and recreational activity-related head injuries are a significant cause of death and disability in the pediatric population. Head injuries from sports are contributing to an increasing proportion of all traumatic brain injuries (TBIs) sustained by children and adolescents.[1] From 2001 to 2009, emergency department (ED) visits for sport-related TBIs increased 62%, which is estimated to be 248 418 visits annually by patients younger than 19 years.[1] The use of helmets has been shown to significantly decrease the risk of nonfatal and fatal head injuries in many sports and recreational activities.[2–5] In addition to head injuries, serious facial injuries can occur during sports and recreational activities. Professional medical organizations, including the American College of Surgeons,[6] American Academy of Orthopedic Surgeons,[7,8] and American Academy of Pediatrics (AAP),[9,10] support helmet use in sports. Additionally, professional sports organizations also advocate for and promote the use of helmets in their sports.[11–14] Although concussions are an important type of head injury, this technical report does not address concussions and their prevention, as this topic is addressed in another AAP clinical report, "Sport-Related Concussion in Children and Adolescents."[15] The high incidence of

abstract

[a]*Division of Emergency Medicine, Boston Children's Hospital, Boston, Massachusetts;* [b]*Division of Pediatric Critical Care Medicine, Mass General for Children, Boston, Massachusetts;* [c]*Department of Pediatrics, Columbia University Irving Medical Center, New York, New York; and* [d]*Department of Pediatrics, Emory University School of Medicine, Atlanta, Georgia*

Dr Lee led the authorship group that included Drs Flaherty, Blanchard, and Agarwal. All authors approve of the final manuscript.

DOI: https://doi.org/10.1542/peds.2022-058878

Accepted for publication Jun 30, 2022

Address correspondence to: Lois K. Lee, MD, MPH. E-mail: lois.lee@childrens.harvard.edu

To cite: Lee LK, Flaherty MR, Blanchard AM, Agarwal M; AAP Council on Injury, Violence, and Poison Prevention. Helmet Use in Preventing Head Injuries in Bicycling, Snow Sports, and Other Recreational Activities and Sports. *Pediatrics.* 2022;150(3):e2022058878

pediatric head injuries and the increasing costs of medical treatment and rehabilitation, as well as lost productivity, reinforce the need for policies and programs to promote helmet use and reduce injury occurrence and severity.[16]

EPIDEMIOLOGY OF SPORT-RELATED HEAD INJURIES

Bicycling

Of all sports and recreational activities, bicycle riding is 1 of the leading causes of head injuries in the pediatric population.[1,17,18] Every year, ~ 26 000 children are seen in EDs for head injuries related to bicycing.[19] Of all bicycle-related injuries, TBIs are the most highly associated with mortality.[20] There is strong evidence that helmets decrease the risk of head injuries in bicycling as well as reduce overall costs for medical care.[21–24] Nevertheless, studies have found the majority of bicycle riders do not wear helmets consistently.[25]

Snow Sports

Snow sports, primarily skiing and snowboarding, are among the other leading causes of recreational sport-related head injuries. Between 1993 and 2003, there were an estimated 78 538 snow sports-related head injuries among children and adolescents treated in EDs.[26] Head injuries account for 7% to 20% of all injuries related to skiing and snowboarding.[27] These injuries are primarily related to falls in which absence of the helmet is associated with an increased risk of TBI.[5,27] In an effort to reduce the burden of head injuries, many national snow sport organizations have championed for universal helmet use on slopes.[11–13]

Other Recreational Activities

Skating and horseback riding are other activities that contribute to substantial numbers of head injuries in children and adolescents. Of skating-related injuries, ice skating is reported to have the highest percentage of head injuries, with 13% to 20% of all injuries being TBIs.[28,29] TBI is also the most common injury encountered in equestrian-related events in patients younger than 18 years, contributing to 14% of all pediatric sports-related injuries.[30] Despite the increased risk of TBIs without the use of helmets, rates of consistent helmet use in all forms of skating and horseback riding in children remain low.[29–32]

Helmet Effectiveness

The real-world effectiveness of helmets has been best studied in bicyclists. A Cochrane review of the protective effect of bicycle helmets based on 5 studies from different countries concluded that helmets decreased the risk of head, brain, and severe brain injury by 63% to 88% for all ages of bicyclists. The review concluded that bicycle helmets meeting national and international standards provide substantial protection to bicyclists of all ages from various types of crashes, including with motor vehicles.[16] Similar protective effects of helmets against bicycle related head and facial injuries have been reported in 2 more recent meta-analyses.[4,33]

Although helmets are known to be protective from head injuries in sports, it has also been postulated that wearing a helmet could increase cervical spine injuries in children because of the concern that head-neck-helmet biomechanics from the helmet weight could potentially exert forces on the neck, increasing the risk of injury.[34] For snow sports (eg, skiing or snowboarding), 1 meta-analysis reported in their pooled analysis that helmets decreased the risk of head injury by 35% (odds ratio [OR]: 0.66; 95% confidence interval [CI]: 0.55 to 0.79; heterogeneity: 75.7%), with no increases in the risk of neck injury.[35] Two meta-analyses of bicycle helmet effectiveness reported no increased risk of cervical spine injury with helmet use.[4,33]

In addition to decreasing the risk of head and facial injuries, helmet use is cost-effective. A Canadian study examined costs related to hospitalization, rehabilitative care, and loss of productivity and compared helmeted and unhelmeted bicyclists (primarily adults). The authors reported significantly higher median hospitalization costs for unhelmeted compared with helmeted cyclists. This difference was magnified further when comparing the costs for unhelmeted bicyclists, who had nearly twice the societal cost, compared with helmeted bicyclists with isolated TBI. There was no reported difference in costs for rehabilitative care or loss of productivity.[24] Another retrospective Canadian study also demonstrated the average ED, diagnostic, operating room, and overall hospital cost for unhelmeted children was significantly higher than for those who were helmeted ($P < .001$).[36]

Helmet Use

Although helmet use is recommended for injury prevention in bicycling, snow sports, and recreational sports (eg, skateboarding or equestrian sports),[9,19,37] there is wide variability in their use during these activities by age, sex, race, ethnicity, and sport. Reasons for not wearing a helmet include cost, discomfort, and lack of belief it is necessary to prevent injury. A 2012 study of national bicycle helmet use in the United States reported that, of children 5 through 17 years of age, only 42% always wore a helmet and 31% never wore a helmet. Helmet use was

decreased among lower-income households, non-White populations, Hispanic populations, and children 10 through 14 years of age. Adult helmet wearing was associated with increased child helmet use.[38]

For other sports, baseline prevalence of helmet use is less well described. Helmet use in pediatrics is associated with younger child age (4 through 12 years old), female sex, and a parent wearing a helmet.[39,40] One national study of 1742 skateboarders and snowboarders with injuries identified in the National Electronic Injury Surveillance System (NEISS) from 2003 to 2012 reported that 52% of those injured were not wearing a helmet at the time of injury.[31] An observational study of 3336 individuals at 3 ski resorts in Nova Scotia demonstrated helmet use varied from 69% to 79%, with similar rates between skiers and snowboarders.[40] A 2018 single-center study of equestrian associated trauma reported that only 23 of 142 children (19.7%) had documented helmet use at the time of injury.[30]

The Nova Scotia study of helmet use surveyed a subgroup of 307 skiers and snowboarders on their reasons for using or not using helmets. Reasons for wearing a helmet included: protection (77%), personal choice (46%), family (44%), and rules (44%). Reasons for not wearing a helmet included: personal choice (29%), comfort (26%), and cost (11%).[40] Similar reasons were reported in a US pediatric study of 206 children (6 through 17 years of age) and an Austrian study of 924 adult skiers and snowboarders.[39,41] One study of inline skaters, skateboarders, and snowboarders and use of personal protective equipment, including helmets, reported discomfort wearing the equipment, lack of perceived need, appearance, cost, and nonuse of equipment by friends as the most common reasons for helmet nonuse. Parents, rules and requirements, friends, siblings, coaches, and celebrity advertisements were cited as reasons for using protective equipment.[42]

Strategies for Increasing Helmet Use

With the variable use of helmets, despite strong evidence of their effectiveness, a multipronged approach is needed to advance helmet use. These approaches include legislation, enforcement of laws and rules, public educational campaigns, and anticipatory guidance from clinicians. In addition, specific helmet focused injury prevention programs in schools, primary care offices, and EDs can also be implemented to increase helmet use within a specific population or community.[43–45] Again, studies on legislation and programs for increasing helmet use in recreational sports has primarily focused on bicyclists.

A 2010 Cochrane narrative review concluded bicycle helmet legislation is effective in increasing helmet use and prevention of head injuries. The helmet legislation in these studies had been enacted only for children.[46] A study after enactment of legislation mandating ski helmet use in children younger than 16 years found helmet wearing increased to 100% after passage of the law; however, there was already a high rate of use (90%) because of educational campaigns before the law.[44]

School programs can also reinforce legislation in increasing helmet use. As part of the Safe Routes to School Program, funding is provided to schools in the United States to promote the safety of walking and bicycling to school, including educating children in bicycling safely to school.[47] Studies have demonstrated that after participation in bike safety school programs, children have improved bike safety knowledge and helmet use behaviors.[48–51]

In addition to school- and community-based programs, the medical setting, including primary care practices and EDs, can be an effective venue for promoting proper helmet use. Primary care clinicians are an important source of anticipatory guidance for a wide range of topics, including injury prevention. A national telephone survey of parents analyzing health care clinician injury prevention counseling in the previous 12 months and children's safety behaviors found a positive association between bicycle helmet counseling for children 5 through 14 years of age and bicycle helmet use ("always use a bicycle helmet in the last 30 days" OR: 1.96; 95% CI: 1.28 to 3.00), adjusted for child and parent demographic factors.[52] Studies in EDs have also been conducted to increase injury prevention counseling in the setting where many injuries initially present.[45,53] A small Canadian ED study to increase bicycle helmet use among patients revealed ED physicians spent less than 4 seconds on injury prevention counseling. Their brief intervention to increase physician counseling showed no long-term effects on actual helmet use. The small sample size was a major limitation but demonstrated the feasibility of providing ED-based injury prevention interventions, although not the long-term effectiveness.[53]

BICYCLE INJURIES AND HELMETS

Helmet Effectiveness

Helmets are highly effective in decreasing the risk and mitigating the severity of head and facial injuries associated with bicycling. For bicycle helmets to effectively prevent or mitigate head injury, they

must fit properly and meet safety standards determined by the Consumer Product Safety Commission, American Society for Testing and Materials, or the Snell Memorial Foundation. Helmets that do not fit properly or meet safety standards may predispose riders to increased risk of head injury.[54]

A Cochrane review analyzing the effectiveness of bicycle helmets determined helmet use in all ages is associated with a significant reduction in head and facial trauma, including injuries resulting from bicycle collisions with motor vehicles. The review included 5 case control studies evaluating the protective effects of helmets among bicyclists with head injury with a summary adjusted OR (aOR) of 0.31 (95% CI: 0.26 to 0.37). Their results indicated that helmets reduce the risk of head injury by 85%, brain injury by 88%, and serious brain injury by 75%. Three of the 5 case control studies focused on upper- and mid-face injuries and reported an overall 65% reduction with helmet use.[16] A 2018 meta-analysis demonstrated a 60% reduction in serious head injuries (95% CI: −65 to −54) and a 53% reduction in traumatic brain injuries (95% CI: −64 to −39), comparing helmeted to unhelmeted cyclists.[4] In addition to decreasing rates of head and facial trauma, bicycle helmet use decreases the severity of injuries. One study examined the association of helmet use with TBI severity (severe TBI defined as head-Abbreviated Injury Score ≥4) among those with intracranial hemorrhage after a bicycle crash. After adjusting for age, sex, race, insurance status, hypotension, Injury Severity Score, and Glasgow Coma Scale score, they found helmeted patients had decreased odds of severe TBI (aOR: 0.49; 95% CI: 0.43 to 0.55), facial fractures (aOR: 0.69; 95% CI: 0.58 to 0.81), and mortality (aOR: 0.56; 95% CI: 0.34 to 0.78).[55]

Although bicycle helmets demonstrate efficacy in decreasing head and facial injuries, current literature suggests no clear impact on neck injuries. Two recent meta-analyses performed subgroup analyses of neck injuries, which demonstrated no beneficial or detrimental effects of helmet use.[4,33] In addition to these meta-analyses, 1 biomechanical study simulating a range of bicycle crash scenarios suggested no increased risk of neck injury from helmet use and a possible benefit.[56]

Helmet Use

Despite the substantial evidence supporting the efficacy of bicycle helmets in preventing injury, rates of helmet use remain low. Two nationally representative, cross-sectional surveys demonstrated that 42% to 48% of children always wear a helmet, and 29% to 31% of children never wear a helmet while riding a bicycle.[38,57] Even lower rates of helmet use are reported in children injured while riding a bicycle. An analysis of pediatric bicycle injuries from the National Trauma Data Bank revealed 22% of children were wearing a bicycle helmet at the time of injury.[58] Recently, public bike share programs have increased access to bicycles. Bike share riders are more likely to ride without a helmet (OR: 4.4; 95% CI: 3.5 to 5.5) compared with personal bike riders.[59] Although most public bike share riders are adults, families and adolescents may also use these programs.

Specific epidemiologic factors influence rates of use and access to bicycle helmets. In a multivariable analysis from 2016, low household income, Hispanic ethnicity, and age 10 through 14 years (in comparison with younger children) were associated with decreased helmet use. Living with an adult who always wore a helmet when bicycling was the strongest predictor of helmet use in children (adjusted prevalence ratio: 1.38; 95% CI: 1.25 to 1.54).[38] A multivariable logistic regression model of helmet use and bicycle crashes found younger children were more likely to be helmeted (children 4–8 years compared with children older than 8 years) (aOR: 1.69; 95% CI, 1.48 to 1.93). Black children (aOR: 0.38; 95% CI: 0.28 to 0.50) and children with public insurance (aOR: 0.33; 95% CI: 0.28 to 0.39) were less likely be helmeted at the time of injury.[58]

Effectiveness of Legislation on Increasing Helmet Use

Bicycle helmet legislation increases rates of helmet use. At the time of this publication, 21 states and the District of Columbia have mandatory bicycle helmet laws for children. Seventeen of the 21 mandatory bicycle helmet laws apply to children ≤15 years, although age requirements vary from ≤17 years to ≤11 years (Fig 1).[60] A Cochrane narrative review of the effects of bicycle helmet legislation on bicycle-related head injuries and helmet use concluded that helmet legislation significantly increases bicycle helmet use, especially when paired with law enforcement measures. No meta-analysis could be conducted as the data were not appropriate for this. The Cochrane review included 6 nonrandomized, controlled, before-and-after studies examining legislation regarding helmet use for children: 3 examined legislation and helmet use, and 3 examined legislation and injuries and fatalities. Helmet use increased significantly between 45% and 84% after introduction of helmet laws or helmet law enforcement.[46] The Second Injury Control and Risk Survey, a nationally representative

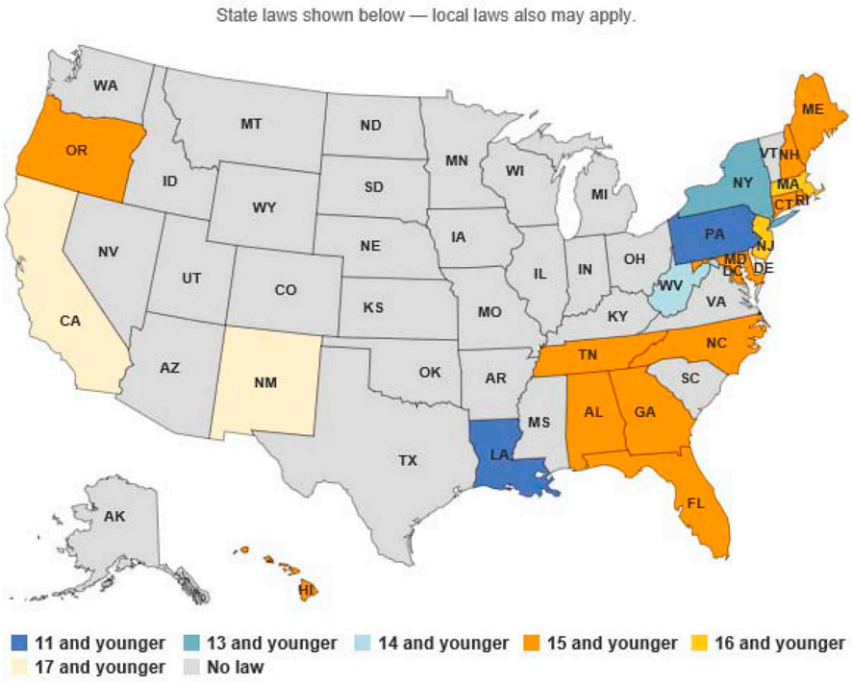

FIGURE 1

State bicycle helmet laws as of July 2022. Figure from the Insurance Institute for Highway Safety (https://www.iihs.org/iihs/topics/laws/bicycle-laws).

survey of helmet use in children, reported similar estimates for the effect of helmet legislation on helmet use. Children living in states without helmet laws were more than 3 times more likely (aOR: 3.47; 95% CI: 2.23 to 5.38) to wear helmets "less than always," compared with "always helmet use" for children living in states with helmet laws.[57]

Helmet legislation also decreases head injuries and fatalities associated with bicycling. The Cochrane review of the effectiveness of bicycle helmet legislation included 3 studies specifically examining the association between legislation and head injury. Two studies reported statistically significant decreases in bicycle related head injuries after legislation. A third study reported a nonsignificant decline in proportion of head injuries.[46] To examine the association of bicycle helmet laws with fatalities and injuries specifically from bicycle versus motor vehicle collisions, Fatality Analysis Reporting System data were analyzed using a clustered Poisson multivariate regression model. This study reported that state helmet laws were associated with a 20% decrease in the rate of bicycle versus motor vehicle-related deaths and injuries, compared with states without helmet laws (adjusted incidence rate ratio: 0.84; 95% CI: 0.70 to 0.98).[61] No evidence suggests a negative effect of mandatory helmet legislation, such as decreasing rates of bicyclists.[46]

Although existing helmet legislation is limited to children, this evidence supports a role for helmet legislation for all ages. Helmet law enforcement is another important component of helmet legislation. A longitudinal, observational study of helmet use in Canada 9, 11, and 14 years after introduction of all-age bicycle helmet legislation showed increased enforcement was associated with increased helmet use.[62]

Effectiveness of Bicycle Helmet Programs

In addition to legislation, injury prevention programs have been developed to promote correct and consistent helmet wearing with the ultimate goal of decreasing bicycle-related head injuries. These programs also provide instruction on safe riding behaviors, including riding location and using bicycle lanes and trails.[63] Multifaceted injury prevention programs have shown the greatest effect on helmet use in children.[45,62,64] These programs typically involve 1 or more components: (1) education, either school, health care, or community based; (2) helmet giveaways; and (3) enforcement and education of existing helmet legislation.[64]

School and community-based programs are important parts of a multipronged approach to increase bicycle helmet use. School-based programs have primarily targeted elementary and middle-school aged children. These programs often include teaching correct helmet fit and education around the protection against head injuries with helmet use.[48,50,51,65] One study evaluated 2 bicycle education programs implemented in New Jersey: a structured school program with no on-street practice time (588 children) and a less structured summer camp program with a 2-mile on-street practice ride (111 children). Overall, there was improvement in knowledge regarding bicycle safety; however, nearly 45% of children had no improvement or decreased scores after the education programs.[48] Another school program using a software program ("Bike Smart") demonstrated increased knowledge and observed helmet placement,

compared with students presented with a childhood safety video.[51] One Canadian study implemented a bicycle safety program for kindergarten children and found improved knowledge regarding appropriate helmet fit.[65] Overall, it remains unclear whether educational programs alone have persistent and long-lasting effects on correct and consistent helmet use.[48,51]

Community programs can also be implemented to increase bicycle riding safety behaviors, including helmet use. A comprehensive program in rural Georgia combined community education of elementary school children and parents with helmet giveaways and enforcement of a helmet law. This program saw helmet wearing children increase from 0% to a range of 30% to 71%, depending on the day of observation.[64]

Bicycle safety programs in medical settings to increase bicycle helmet use in children have also been studied. One prospective study conducted in a primary care pediatric office assessed all patients and their siblings 4 to 18 years of age during well-child visits for helmet use and fit for bicycling, in-line skating, scootering, and skateboarding. Helmet use was highest ("always" or "almost always") for bicycling (73%) and less for in-line skating (69%), scooter riding (58%), and skateboarding (50%). Teenagers used helmets less compared with preadolescents ($P < .001$). Only 4% of children (20 of 479) passed the entire evaluation for helmet fit: (1) helmet condition, (2) appropriate size of helmet, (3) correct location of strap, and (4) helmet stability on the head. The authors concluded educating about correct helmet use and fit during sports was feasible during well-child visits; however, no follow-up was conducted on helmet use or retention of proper fitting technique over time.[66] A prospective randomized study of 12 pediatric practices examined an anticipatory guidance intervention during well-child visits for children from fifth and sixth grades to eighth and ninth grades. The practices were divided into 2 intervention arms focused on either: (1) alcohol and cigarette use; or (2) bicycle helmets, gun storage, and seatbelt safety. Of the 3525 children enrolled, 36-month follow-up data were obtained for 2183. Only bicycle helmet use improved, with a reported decrease in the child not using a bicycle helmet in the last year compared with the alcohol and cigarette use intervention group (OR: 0.76; 95% CI: 0.63 to 0.92).[43] Primary care clinician education and counseling on bicycle helmet use can be an effective way of increasing helmet use in school-aged children and teenagers.

In addition to primary care offices, bicycle safety programs promoting helmet use can also be implemented in the ED. One ED-based education program implemented an intervention combining personal counseling sessions with behavioral contracts and some in the intervention group were also fitted and provided with a helmet. Children in the intervention group were compared with a control group with no safety intervention.[45] The 1-month telephone follow-up to assess bicycle helmet use was completed for 148 children (67%), but only 69 children had ridden a bicycle during that month (38 intervention group: 20 provided helmets, 18 counseling only; 31 control group). This low number limited the power for the analysis, with children 66% of children (25 of 38) in the intervention group reporting "never failing to wear a helmet while bicycling" compared with 42% (13 of 31) in the control group (OR: 2.66; 95% CI: 0.90 to 7.95).[45] These studies reveal programs using multiple approaches to injury prevention in different venues may be most successful in increasing pediatric helmet use while bicycling.

SNOW SPORTS INJURIES AND HELMETS

Helmet Effectiveness

Skiing and snowboarding (henceforth collectively termed "snow sports") are popular activities for children and youth. Although these activities are popular forms of competitive and recreational sports, like bicycling, there are associated risks of head, neck, and extremity injuries. Several reviews conducted on the effectiveness of helmets in snow sports have concluded there is strong evidence that helmets decrease head injuries.[35,67–69] One meta-analysis based on 6 studies reported that helmets were effective in decreasing head injuries in snow sports with an OR of 0.58 (90% CI: 0.51 to 0.77). It also concluded that helmets are possibly beneficial in preventing neck injuries (OR: 0.82; 90% CI: 0.64 to 1.04); however, only 3 studies were included in this analysis, limiting the overall power of this analysis.[69] Another meta-analysis analyzed 9 case-control studies comparing injured skiers and snowboarders with uninjured controls or controls with a nonhead or nonneck injury. This pooled analysis similarly demonstrated that helmets decreased the overall risk of head injury (OR: 0.66; 95% CI: 0.55 to 0.79) and for specific subpopulations (Table 1).[35]

Although helmets are designed to prevent head injury, the concern has been raised that helmet use could increase the risk of neck injury in snow sports. Multiple studies have not found an association between helmets and neck injuries.[35,67,68] A meta-analysis of 6 studies examining the risk of neck injury and

TABLE 1 Effectiveness of Helmets in Decreasing Risk of Head Injury in Snow Sports

Characteristic[a]	Number of Studies	OR (95% CI)
Overall head injury	9	
Age group, y		0.66 (0.55 to 0.79)
<13	4	0.41 (0.28 to 0.62)
13–24	1	0.80 (0.69 to 0.89)
>25	1	1.13 (0.93 to 1.36)
Sex		
Female	1	0.80 (0.70 to 0.92)
Male	1	0.98 (0.80 to 1.19)
Ability		
Beginner	1	0.69 (0.53 to 0.89)
Intermediate	1	0.86 (0.72 to 1.02)
Expert	1	0.92 (0.77 to 1.09)
Activity		
Skiing	2	0.82 (0.69 to 0.98)
Snowboarding	2	0.83 (0.75 to 0.98)
Location		
Park or off-piste (backcountry or out of bounds)	1	0.26 (0.14 to 0.50)
Prepared runs	1	0.45 (0.31 to 0.64)
Life-related	1	0.52 (0.19 to 1.38)
Age and activity		
<13 y and skiing	1	0.40 (0.20 to 0.96)
<13 y and snowboarding	1	0.18 (0.04 to 0.74)
13–20 y and skiing	1	0.52 (0.23 to 1.19)
13–20 y and snowboarding	1	0.56 (0.32 to 0.95)
>20 y and skiing	1	0.43 (0.18 to 1.02)
>20 y and snowboarding	1	0.18 (0.03 to 0.39)

[a] Adapted from "The effect of helmets on the risk of head and neck injuries among skiers and snowboarders: a meta-analysis."[35]

helmet use found no increased risk (OR: 0.89; 95% CI: 0.72 to 1.09).[35]

There have also been concerns that helmet use could increase risk-taking behavior among skiers and snowboarders. The results have been mixed for studies examining more aggressive or dangerous participation in the context of wearing a helmet and the increased risk of injuries. One survey of skiers and snowboarders at a single ski resort concluded that among inconsistent helmet users, risk-taking behavior and risk compensation was associated with males, younger ages, snowboarding, self-rated expert level, and more time on the mountain.[70] Several reviews of the available evidence concluded that overall, injury risk is not greater with helmet use in snow sports.[35,68]

Effectiveness of Legislation on Increasing Helmet Use

Although the effectiveness of helmets in decreasing head injuries in snow sports is well established, helmets are still not worn universally. In 2011, the state of New Jersey and the province of Nova Scotia passed legislation mandating helmet use for downhill skiing and snowboarding. Several European countries also have laws mandating helmet use in children.[44] The New Jersey law requires all people younger than 18 years to wear a helmet when skiing or snowboarding.[71] The Nova Scotia law applies to people younger than 16 years. The effectiveness of this law was studied with direct observations of 3887 skiers and snowboarders at the 3 ski resorts in Nova Scotia with 100% helmet use. This was increased from a baseline of 90% of skiers and snowboarders observed to use helmets after an educational campaign. The authors hypothesized the strong provincial helmet laws for other wheeled activities (eg, bicycling) may have resulted in this population's strong response to the legislation.[44]

Effectiveness of Snow Sports Helmet Programs

There are limited studies on the effectiveness of education programs in increasing helmet use in children participating in snow sports. One prospective, randomized interventional study examined the effectiveness of education in teaching seventh-grade students about snow sports safety. Students were shown a video including information on proper helmet use as well as other safety measures when participating in snow sports. Tests administered before and after students viewed the video demonstrated improved knowledge in the intervention student group, but the study was not powered to detect any differences in injury rates.[72] In Nova Scotia, before passage of the snow sport helmet law, an educational campaign was launched to increase awareness about helmet effectiveness to increase voluntary helmet use. Helmet use was observed to increase from a baseline of 74% to 90% with this educational program. Use was higher in younger athletes, with nearly all children and 97% of adolescents were wearing helmets.[44]

OTHER RECREATIONAL SPORTS, INJURIES, AND HELMETS

In addition to bicycling and snow sports, helmets play a critical role in decreasing pediatric head injuries in many other sports and recreational activities. At present, there are varying levels of evidence supporting the use of helmets in other nonmotorized wheeled activities beyond bicycling, skating, equestrian events, and organized sports such as, football and baseball, in pediatric populations. There is a dearth of literature on the effectiveness of policies or programs to increase helmet use and decrease head injuries in these other recreational sports.

Skating and Other Nonmotorized Wheeled Activities

Skating and other nonmotorized wheeled activities (eg skateboarding and scooter riding), as a whole, have remained popular over time.[28] However, the injuries sustained vary based on activity. Head injuries are far more common in ice skaters compared with other skating activities.[28,29] In 1 study utilizing 11 years of NEISS data, there were an estimated 25 915 intracranial injuries and 17 352 contusions and/or abrasion injuries of the head attributable to skating sports. There was a significantly higher proportion of children with head injuries attributable to ice skating (13.3%) compared with roller skating (4.4%; risk ratio [RR]: 3.05; 95% CI: 3.00 to 3.11; $P < .001$) or in-line skating (5.0%; RR: 2.68; 95% CI: 2.64 to 2.72; $P < .001$).[28] Similar injury patterns between ice skating and skateboarding were documented in another single-site study. This is believed to be attributable to different fall mechanics, as ice skaters and skateboarders tend to fall backward, impeding their attempts to break falls with upper extremities.[29] Ice is also a low-friction surface, which likely alters the biomechanics and injury patterns of falls.[28]

Helmet Effectiveness

Research on helmet effectiveness for nonmotorized wheeled activities is limited. A multicenter study of sport-related head injuries found a decreased odds of head injury in helmeted compared with unhelmeted children for skateboarding (aOR: 0.33; 95% CI: 0.23 to 0.46), in-line skating (aOR: 0.33; 95% CI: 0.14 to 0.79), and scootering (aOR: 0.53; 95% CI: 0.33 to 0.86). No difference was found for hospitalization.[18] Similarly, a retrospective study of 5 years of National Trauma Data Bank data on skateboard injuries found that helmet use reduced the risk of TBI in children and adolescents (aOR: 0.45; 95% CI: 0.27 to 0.75, $P = .002$).[73]

Another multicenter study documented helmeted compared with unhelmeted children injured on a nonmotorized wheeled vehicle were less likely to be admitted to the hospital (OR: 0.50; 95% CI: 0.25 to 1.00; $P = .05$) and sustain a major head injury (OR: 0.31; 95% CI: 0.12 to 0.76; $P = .009$). This analysis pooled together multiple injury mechanisms, including bicycles, scooters, skateboards, and in-line skates.[3] Another study using NEISS data revealed children injured when unhelmeted were more likely to sustain a head injury (OR: 1.96; 95% CI: 1.44 to 2.69; $P = .002$). This analysis also pooled together pediatric skateboarders and snowboarders.[31]

Equestrian Events

Multiple studies have also been conducted on helmet use for children participating in equestrian events (eg, horseback riding), bull riding, and other rodeo-based activities. In a single-center, 10-year retrospective review of 312 pediatric patients injured in equestrian-related activities, helmet use was associated with decreased injury severity scores (7.1 versus 11.3; $P < .01$), TBI (32.4% versus 55.3%; $P = .03$), and ICU admission rate (10.7% versus 29%; $P = .05$). The multivariate logistic regression analysis reported lack of helmet use was found to be an independent predictor of TBI (OR: 2.5; 95% CI: 1.1 to 6.3).[30] A more detailed study using pairs matched by age, sex, and horseback riding trauma mechanism examined pediatric and adult patients with equestrian related head injuries. Intracranial hemorrhage was reported to be more common in unhelmeted children (OR: 9.0; 95% CI: 1.64 to 49.45). The authors concluded that the relative risk reduction of intracranial bleeding by wearing a safety helmet was 96%.[32]

CONCLUSIONS

Sport-related head and facial injuries can result in serious morbidity and mortality. Research has demonstrated that helmets decrease the risk of head and facial injuries from sports and recreational activity in children. The evidence is strongest for bicycling and has also been demonstrated for snow sports and other recreational sports.[16,21,33,74] For all ages of bicyclists, helmets decrease the risk of head, brain, and severe brain injury by 63% to 88%.[16] Despite the proven effectiveness of helmets in decreasing head injuries, there is variable use of helmets while participating in recreational sports.

To improve helmet use, helmet legislation has the strongest evidence for increasing use and preventing head injuries in bicycling and skiing, although enforcement is variable.[44,46] School and community programs have also demonstrated effectiveness in improving helmet use for bicycling and snow sports. There is a dearth of literature for other sports.

The medical community, including primary care and ED clinicians, can have a pivotal role in promoting the use of helmets in sports and recreation by offering anticipatory guidance in the universal use of helmets when riding bikes, skiing, snowboarding, skating, and horseback riding. Primary care clinicians often have lifelong and trusting relationships with their patients and have, thus, been shown to increase helmet use and adherence to safe behaviors with injury prevention counseling to their patients and parents.[52] This guidance can extend beyond the

patient relationship to include advocating for improved helmet requirements in organized versions of these sports and in consistent positive portrayal of helmets in the media.

With the increasing participation of children and adolescents in bicycling and recreational sports, increasing helmet use is critical for decreasing fatalities and mitigating injuries. There is strong evidence for the effectiveness of helmet legislation in decreasing head injuries and fatalities in pediatrics. Ultimately, to improve helmet use and decrease death and injury, a multipronged approach including legislation, enforcement of laws, and community- and medical clinician-based education campaigns and programs needs to be implemented. As pediatric clinicians, we want to keep children active while keeping them safe, and helmet use is 1 proven means for accomplishing this.

LEAD AUTHORS

Lois K. Lee, MD, MPH, FAAP

Michael R. Flaherty, DO
Ashley M. Blanchard, MD, MSc, FAAP
Maneesha Agarwal, MD, FAAP
Council on Injury, Violence, and Poison Prevention, 2019-2020
Benjamin Hoffman, MD, FAAP, Chairperson
Phyllis F. Agran, MD, MPH, FAAP
Michael Hirsh, MD, FAAP
Brian Johnston, MD, MPH, FAAP
Sadiqa Kendi, MD, FAAP
Lois K. Lee, MD, MPH, FAAP
Kathy Monroe, MD, FAAP
Judy Schaechter, MD, MBA, FAAP
Milton Tenenbein, MD, FAAP
Mark R. Zonfrillo, MD, MSCE, FAAP
Kyran Quinlan, MD, MPH, FAAP, Immediate Past Chairperson

LIAISONS

Lynne Janecek Haverkos, MD, MPH, FAAP – National Institute of Child Health and Human Development
Jonathan D. Midgett, PhD – Consumer Product Safety Commission
Bethany Miller, MSW, Med – Health Resources and Services Administration
Judith Qualters, PhD, MPH – Centers for Disease Control and Prevention
Alexander W. (Sandy) Sinclair – US Department of Transportation
Richard Stanwick, MD, FAAP – Canadian Pediatric Society

STAFF

Bonnie Kozial

ABBREVIATIONS

AAP: American Academy of Pediatrics
CI: confidence interval
ED: emergency department
NEISS: National Electronic Injury Surveillance System
OR: odds ratio
TBI: traumatic brain injury

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FUNDING: No external funding.

FINANCIAL/CONFLICT OF INTEREST DISCLOSURE: None.

COMPANION PAPER: A companion to this article can be found online at www.pediatrics.org/cgi/doi/10.1542/peds.2022-058877

REFERENCES

1. Gilchrist J, Thomas KE, Xu L, McGuire LC, Coronado V. Nonfatal traumatic brain injuries related to sports and recreation activities among persons aged ≤19 years–United States, 2001-2009. *MMWR Morb Mortal Wkly Rep*. 2011;60(39):1337–1342
2. Bandte A, Fritzsche FS, Emami P, Kammler G, Püschel K, Krajewski K. Sport-related traumatic brain injury with and without helmets in children. *World Neurosurg*. 2018;111:e434–e439
3. Ong JS, Soundappan SV, Adams S, Adams S. Helmet use in bicycles and non-motorised wheeled recreational vehicles in children. *J Paediatr Child Health*. 2018;54(9):968–974
4. Høye A. Bicycle helmets - to wear or not to wear? A meta-analyses of the effects of bicycle helmets on injuries. *Accid Anal Prev*. 2018;117:85–97
5. Bailly N, Laporte JD, Afquir S, et al. Effect of helmet use on traumatic brain injuries and other head injuries in alpine sport. *Wilderness Environ Med*. 2018;29(2):151–158
6. American College of Surgeons. Statement on bicycle safety and the promotion of bicycle helmet use. Available at: https://www.facs.org/about-acs/statements/75-bicycle-safety. Accessed March 5, 2019
7. American Academy of Orthopedic Surgeons. Bicyclist, motorcycle and passenger safety. Available at: https://aaos.org/contentassets/1cd7f41417ec4dd4b5c4c48532183b96/1110---bicyclist-motorcycle-and-passenger-safety1.pdf. Accessed March 6, 2019
8. American Academy of Orthopedic Surgeons. In-line skating and skateboarding safety. Available at: https://www.aaos.org/contentassets/1cd7f41417ec4dd4b5c4c48532183b96/1127---

in-line-skating-and-skateboarding-safety.pdf. Accessed March 8, 2019

9. American Academy of Pediatrics Committee on Injury and Poison Prevention. Bicycle helmets. *Pediatrics*. 2001;108(4):1030–1032
10. Lee LK, Flaherty MR, Blanchard AM, Agarwal M. Helmet use in preventing head injuries in bicycling, snow sports, and other recreational activities and sports. *Pediatrics*. 2022;150(3):e2022058877
11. Canadian Ski Council. Helmet safety. Available at: https://www.skicanada.org/safety/why-wear-a-helmet/. Accessed December 10, 2018
12. Nation Ski Areas Association. Lids on kids. Available at: https://www.nsaa.org/safety-programs/lids-on-kids/. Accessed December 10, 2018
13. National Ski Patrol. Safety on the slopes. Available at: https://www.nsp.org/. Accessed December 10, 2018
14. Lacrosse US. US Lacrosse Sports Science & Safety Committee position statement on helmet use in lacrosse. Available at: https://www.uslacrosse.org/safety/equipment/usl-position-statement-on-helmets. Accessed March 5, 2019
15. Halstead ME, Walter KD, Moffatt K; Council on Sports Medicine and Fitness. Sport-related concussion in children and adolescents. *Pediatrics*. 2018;142(6):e20183074
16. Thompson DC, Rivara FP, Thompson R. Helmets for preventing head and facial injuries in bicyclists. *Cochrane Database Syst Rev*. 2000;(2):CD001855
17. Kaushik R, Krisch IM, Schroeder DR, Flick R, Nemergut ME. Pediatric bicycle-related head injuries: a population-based study in a county without a helmet law. *Inj Epidemiol*. 2015;2(1):16
18. Lindsay H, Brussoni M. Injuries and helmet use related to non-motorized wheeled activities among pediatric patients. *Chronic Dis Inj Can*. 2014;34(2–3):74–81
19. Safekids Worldwide. Bicycle, skate and skateboard safety fact sheet (2016) fatalities. Available at: http://www.safekidssavannah.org/forms/BicycleSkateAndSkateboardSafety.pdf. Accessed August 30, 2018
20. Williams C, Weston R, Feinglass J, Crandall M. Pediatric bicycle helmet legislation and crash-related traumatic brain injury in Illinois, 1999-2009. *J Surg Res*. 2018;222:231–237
21. Thompson DC, Rivara FP, Thompson RS. Effectiveness of bicycle safety helmets in preventing head injuries. a case-control study. *JAMA*. 1996;276(24):1968–1973
22. Thompson RS, Rivara FP, Thompson DC. A case-control study of the effectiveness of bicycle safety helmets. *N Engl J Med*. 1989;320(21):1361–1367
23. Olivier J, Radun I. Bicycle helmet effectiveness is not overstated. *Traffic Inj Prev*. 2017;18(7):755–760
24. Costa CK, Dagher JH, Lamoureux J, de Guise E, Feyz M. Societal cost of traumatic brain injury: a comparison of cost-of-injuries related to biking with and without helmet use. *Brain Inj*. 2015;29(7–8):843–847
25. Klein KS, Thompson D, Scheidt PC, Overpeck MD, Gross LA; HBSC International Investigators. Factors associated with bicycle helmet use among young adolescents in a multinational sample. *Inj Prev*. 2005;11(5):288–293
26. Graves JM, Whitehill JM, Stream JO, Vavilala MS, Rivara FP. Emergency department reported head injuries from skiing and snowboarding among children and adolescents, 1996-2010. *Inj Prev*. 2013;19(6):399–404
27. Summers Z, Teague WJ, Hutson JM, Palmer CS, Jowett HE, King SK. The spectrum of pediatric injuries sustained in snow sports. *J Pediatr Surg*. 2017;52(12):2038–2041
28. Knox CL, Comstock RD, McGeehan J, Smith GA. Differences in the risk associated with head injury for pediatric ice skaters, roller skaters, and in-line skaters. *Pediatrics*. 2006;118(2):549–554
29. McGeehan J, Shields BJ, Smith GA. Children should wear helmets while ice-skating: a comparison of skating-related injuries. *Pediatrics*. 2004;114(1):124–128
30. Short SS, Fenton SJ, Scaife ER, Bucher BT. Helmet under-utilization by children during equestrian events is associated with increased traumatic brain injury. *J Pediatr Surg*. 2018;53(3):545–547
31. Sadeghian H, Nguyen B, Huynh N, Rouch J, Lee SL, Bazargan-Hejazi S. Factors influencing helmet use, head injury, and hospitalization among children involved in skateboarding and snowboarding accidents. *Perm J*. 2017;21:16–161
32. Bier G, Bongers MN, Othman A, et al. Impact of helmet use in equestrian-related traumatic brain injury: a matched-pairs analysis. *Br J Neurosurg*. 2018;32(1):37–43
33. Olivier J, Creighton P. Bicycle injuries and helmet use: a systematic review and meta-analysis. *Int J Epidemiol*. 2017;46(1):278–292
34. Hagel BE, Russell K, Goulet C, Nettel-Aguirre A, Pless IB. Helmet use and risk of neck injury in skiers and snowboarders. *Am J Epidemiol*. 2010;171(10):1134–1143
35. Russell K, Christie J, Hagel BE. The effect of helmets on the risk of head and neck injuries among skiers and snowboarders: a meta-analysis. *CMAJ*. 2010;182(4):333–340
36. Michael PD, Davenport DL, Draus JM Jr. Bicycle helmets save more than heads: experience from a pediatric level I trauma hospital. *Am Surg*. 2017;83(9):1007–1011
37. Committee on Injury and Poison Prevention; American Academy of Pediatrics. Skateboard and scooter injuries. *Pediatrics*. 2002;109(3):542–543
38. Jewett A, Beck LF, Taylor C, Baldwin G. Bicycle helmet use among persons 5 years and older in the United States, 2012. *J Safety Res*. 2016;59:1–7
39. Provance AJ, Engelman GH, Carry PM. Implications of parental influence on child/adolescent helmet use in snow sports. *Clin J Sport Med*. 2012;22(3):240–243
40. Fenerty L, Thibault-Halman G, Bruce BS, et al. Helmets for skiing and snowboarding: who is using them and why. *J Trauma Acute Care Surg*. 2013;74(3):895–900
41. Ruedl G, Kopp M, Rumpold G, Holzner B, Ledochowski L, Burtscher M. Attitudes regarding ski helmet use among helmet wearers and non-wearers. *Inj Prev*. 2012;18(3):182–186
42. Kroncke EL, Niedfeldt MW, Young CC. Use of protective equipment by

adolescents in inline skating, skateboarding, and snowboarding. *Clin J Sport Med.* 2008;18(1):38–43

43. Stevens MM, Olson AL, Gaffney CA, Tosteson TD, Mott LA, Starr P. A pediatric, practice-based, randomized trial of drinking and smoking prevention and bicycle helmet, gun, and seatbelt safety promotion. *Pediatrics.* 2002;109(3):490–497
44. Fenerty L, Heatley J, Young J, et al. Achieving all-age helmet use compliance for snow sports: strategic use of education, legislation and enforcement. *Inj Prev.* 2016;22(3): 176–180
45. Bishai D, Qureshi A, Cantu N, Parks C. Contracting with children and helmet distribution in the emergency department to improve bicycle helmet use. *Acad Emerg Med.* 2003;10(12):1371–1377
46. Macpherson A, Spinks A. Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. *Cochrane Database Syst Rev.* 2007;(2): CD005401
47. National Center for Safe Routes to School. Safe routes. Available at: www.saferoutesinfo.org/. Accessed August 10, 2018
48. Lachapelle U, Noland RB, Von Hagen LA. Teaching children about bicycle safety: an evaluation of the New Jersey Bike School program. *Accid Anal Prev.* 2013; 52:237–249
49. Hooshmand J, Hotz G, Neilson V, Chandler L. BikeSafe: evaluating a bicycle safety program for middle school aged children. *Accid Anal Prev.* 2014;66:182–186
50. Kirsch SED, Pullen N. Evaluation of a school-based education program to promote bicycle safety. *Health Promot Pract.* 2003;4(2):138–145
51. McLaughlin KA, Glang A. The effectiveness of a bicycle safety program for improving safety-related knowledge and behavior in young elementary students. *J Pediatr Psychol.* 2010;35(4):343–353
52. Chen J, Kresnow MJ, Simon TR, Dellinger A. Injury-prevention counseling and behavior among US children: results from the second Injury Control and Risk Survey. *Pediatrics.* 2007; 119(4):e958–e965
53. Sullivan E, Fuller D, Paterson QS, Huffman S, Challa S, Woods R. Emergency physicians as human billboards for injury prevention: a randomized controlled trial. *CJEM.* 2017;19(4):277–284
54. Rivara FP, Astley SJ, Clarren SK, Thompson DC, Thompson RS. Fit of bicycle safety helmets and risk of head injuries in children. *Inj Prev.* 1999;5(3): 194–197
55. Joseph B, Azim A, Haider AA, et al. Bicycle helmets work when it matters the most. *Am J Surg.* 2017;213(2): 413–417
56. McNally DS, Whitehead S. A computational simulation study of the influence of helmet wearing on head injury risk in adult cyclists. *Accid Anal Prev.* 2013;60:15–23
57. Dellinger AM, Kresnow MJ. Bicycle helmet use among children in the United States: the effects of legislation, personal and household factors. *J Safety Res.* 2010;41(4):375–380
58. Gulack BC, Englum BR, Rialon KL, et al. Inequalities in the use of helmets by race and payer status among pediatric cyclists. *Surgery.* 2015;158(2):556–561
59. Fischer CM, Sanchez CE, Pittman M, et al. Prevalence of bicycle helmet use by users of public bikeshare programs. *Ann Emerg Med.* 2012;60(2):228–231
60. Insurance Institute for Highway Safety. Bicycle helmet use. Available at: https://www.iihs.org/iihs/topics/laws/bicyclelaws. Accessed July 18, 2022
61. Meehan WP III, Lee LK, Fischer CM, Mannix RC. Bicycle helmet laws are associated with a lower fatality rate from bicycle-motor vehicle collisions. *J Pediatr.* 2013;163(3):726–729
62. Huybers S, Fenerty L, Kureshi N, et al. Long-term effects of education and legislation enforcement on all-age bicycle helmet use: a longitudinal study. *J Community Health.* 2017;42(1):83–89
63. Karl FM, Smith J, Piedt S, Turcotte K, Pike I. Applying the health action process approach to bicycle helmet use and evaluating a social marketing campaign. *Inj Prev.* 2018;24(4):288–295
64. Gilchrist J, Schieber RA, Leadbetter S, Davidson SC. Police enforcement as part of a comprehensive bicycle helmet program. *Pediatrics.* 2000;106(1 Pt 1): 6–9
65. Cusimano MD, Faress A, Luong WP, et al. Evaluation of a bicycle helmet safety program for children. *Can J Neurol Sci.* 2013;40(5):710–716
66. Parkinson GW, Hike KE. Bicycle helmet assessment during well visits reveals severe shortcomings in condition and fit. *Pediatrics.* 2003;112(2):320–323
67. Cusimano MD, Kwok J. The effectiveness of helmet wear in skiers and snowboarders: a systematic review. *Br J Sports Med.* 2010;44(11):781–786
68. Haider AH, Saleem T, Bilaniuk JW, Barraco RD; Eastern Association for the Surgery of Trauma Injury ControlViolence Prevention Committee. An evidence-based review: efficacy of safety helmets in the reduction of head injuries in recreational skiers and snowboarders. *J Trauma Acute Care Surg.* 2012;73(5): 1340–1347
69. Hume PA, Lorimer AV, Griffiths PC, Carlson I, Lamont M. Recreational snow-sports injury risk factors and countermeasures: a meta-analysis review and haddon matrix evaluation. *Sports Med.* 2015;45(8):1175–1190
70. Willick SE, Wagner G, Ericson D, Josten G, Teramoto M, Davis J. Helmet use and risk-taking behavior among skiers and snowboarders. *Clin J Sport Med.* 2017; 29(4):329–335
71. On the Snow. New Jersey's helmet law now effective. Available at: https://www.onthesnow.com/news/a/104732/new-jersey-s-helmet-law-now-effective. Accessed December 11, 2018
72. Cusimano M, Luong WP, Faress A, Leroux T, Russell K. Evaluation of a ski and snowboard injury prevention program. *Int J Inj Contr Saf Promot.* 2013;20(1):13–18
73. Lustenberger T, Talving P, Barmparas G, et al. Skateboard-related injuries: not to be taken lightly. a national trauma databank analysis. *J Trauma.* 2010;69(4): 924–927
74. Cusimano MD, Kwok J. Skiers, snowboarders, and safety helmets. *JAMA.* 2010;303(7):661–662