Estimates of the Incidence and Costs Associated With Handlebar-Related Injuries in Children

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Background: The US Consumer Product Safety Commission is considering handlebar regulation regarding impact performance to address the risk of abdominal and pelvic organ injuries in bicyclists.

Objective: To provide national estimates of incidence and costs of handlebar-related abdominal and pelvic organ injuries.

Design and Setting: Censuses of hospital discharge data from 19 states were extrapolated to determine national estimates. The percentage of abdominal and pelvic injuries associated with handlebars was estimated based on a case series from a pediatric trauma center. Costs were estimated using standard methods.

Participants: All subjects younger than 20 years treated as inpatients and discharged from acute care hospitals for non–motor vehicle bicycle-related injury in 19 states in 1997 and at a pediatric trauma center located in one of the states between January 1, 1996, and December 31, 2000.

Main Outcome Measures: Incidence of bicycle-related handlebar abdominal and pelvic organ injury, total hospital charges, lifetime medical payments, lifetime productivity loss, and lifetime monetized quality-adjusted life-years.

Results: An estimated 1147 subjects (95% confidence interval, 1082-1215; 1.49 per 100000 subjects 19 years and younger) in the United States had serious non–motor vehicle–involved bicycle-related abdominal or pelvic organ injury leading to hospitalization in 1997, and 886 (95% confidence interval, 828-944; 1.15 per 100000 subjects 19 years and younger) of these injuries likely were associated with handlebars. The estimated national costs associated with handlebar-related abdominal and pelvic organ injuries were $9.6 million in total hospital charges, $10.0 million in lifetime medical costs (including claims processing), $11.5 million in lifetime productivity losses, and $503.9 million in lifetime monetized quality-adjusted life-years.

Conclusions: Handlebar-related abdominal and pelvic organ injuries pose a serious health risk to children and result in substantial health care costs. Requirements for safer handlebar designs may provide one avenue to achieve a health and economic benefit.

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FOR MORE than 30 years, the danger of serious abdominal and pelvic organ injuries posed by bicycle handlebars has been known. Impact with handlebars has been shown to produce traumatic abdominal wall hernia[1-4]; renal, intestinal, liver, splenic, and pancreatic injuries[5-11]; abdominal wall rupture[12]; abdominal aorta rupture[13]; transection of the common bile duct[14]; traumatic arterial occlusion[15]; groin injuries[16,17]; and death.[18] These injuries typically occur in the setting of otherwise minor incidents—falls from bicycles not involving motor vehicle crashes, during which the handlebars act as blunt spears, causing injuries on impact.[19] Based on the known injury risk and the availability of safer handlebar designs, the US Consumer Product Safety Commission is considering regulation of the performance of handlebars regarding their energy dissipation and distribution during impact and is reviewing comments to a petition posted in the *Federal Register*.[20]

Previous reports of the incidence of handlebar-related injuries have been limited to the experience of individual health care settings. To our knowledge, there has been no previous attempt to extrapolate these data to provide national estimates of the incidence or costs of handlebar-related abdominal and pelvic organ injuries in child bicyclists. The purpose of this study is to provide estimates of the national perspective on the health and economic burden of handlebar-related abdominal and pelvic organ injuries to children.

SUBJECTS AND METHODS

Previous literature[19] has demonstrated that handlebar-related injuries occur predominantly with bicycle crashes or falls not involving motor vehicles; therefore, the analyses in this article were restricted to non–motor vehicle bicycle crashes and falls. The incidence of hospitalization for bicycle-related abdominal and pelvic organ injuries for subjects younger than 20 years was determined from a census of hospital discharge data from 19 states for 1997. The estimated proportion of these injuries that was related to handlebars was determined from a case series analysis in a hospital in one of these states. These data were extrapolated, based on US Census information, to arrive at national estimates. Costs associated with these injuries were estimated, based on accepted health economic procedures described herein.

19-STATE HOSPITAL DISCHARGE DATA FOR 1997

A large multistate database was created by 3 of us (H.B.W., T.R.M., and B.A.L.) that incorporated a census of 1997 acute care hospital discharge data obtained from the following 19 states: Arizona, California, Florida, Maine, Maryland, Massachusetts, Michigan, Nebraska, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, South Carolina, Utah, Vermont, Virginia, Washington, and Wisconsin. These states represented 52% of the children in the United States, based on the 1997 US Census (US Bureau of the Census, Suitland, Md). Participating states had either mandatory E-coding or high compliance with voluntary reporting of E-codes. The data showed a 92.6% E-code completion rate for all abdominal and pelvic injuries to subjects younger than 20 years.

The database included information regarding the nature and cause of injury (*International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]* diagnosis codes and external cause of injury codes, or E-codes),[21] associated hospital costs, patient demographics, and other variables. Injury severity was assigned to each case using a computerized injury coder (ICDMAP-90; Tri-Analytics, Inc, Bel Air, Md), which assigns Abbreviated Injury Scale (AIS) codes,[22] Injury Severity Scores (mathematically computed from ≥1 AIS scores), and AIS-90 body regions, among other variables. E-codes were used to identify children with a bicycle-related injury and to differentiate between bicycle crashes that did and did not involve motor vehicles. Crashes not involving motor vehicles were defined as those including code E826.1 or E826.9.

1996 THROUGH 2000 CHOP TRAUMA REGISTRY

The Children's Hospital of Philadelphia (CHOP) is the level I pediatric trauma center for southeastern Pennsylvania and the Delaware Valley (1 of 2 level I pediatric trauma centers in the state). Its trauma registry is a census of all trauma admissions to the institution. The registry identified children with a bicycle-related abdominal or pelvic injury between January 1, 1996, and December 31, 2000. Registry information was supplemented by data from medical office charts, trauma histories, and physical examination forms. Data reviewed included age, injury description and AIS codes, and textual description of injury circumstances. The records of patients who were admitted to the hospital with an AIS score of 2 or greater abdominal or pelvic organ injuries after non–motor vehicle–involved bicycle crashes (codes E826.1 or E826.9) were reviewed. Handlebar-related injuries were defined as those cases in which the medical record documented that the handlebar impact caused the injury (eg, "struck handlebars"). Telephone follow-up with the injured child and his or her family was used to verify the information in the medical record.

Case selection and stratification criteria were similar for the 19-state hospital discharge database and the retrospective medical chart review at CHOP. Subjects were selected based on age and *ICD-9-CM* E-codes for crashes not involving motor vehicles (as already defined) and diagnostic codes for abdominal or pelvic organ injury that would translate to an AIS score of 2 or greater, indicating presence of organ damage. The *ICD-9-CM* diagnosis codes that were included were 863 through 868, 878, 879.2 through 879.5, 902, 922.2, 922.4, 926.0, and 947.3 through 947.4.

Subjects with the following criteria were excluded from our analysis: abdominal or pelvic injuries occurring in injury circumstances not involving bicycle crashes; motor vehicle–related bicycle crashes (eg, code E81X.6); bicycle crash victims 20 years and older; minor handlebar-related injuries, including superficial contusions, abrasions, and lacerations (AIS <2 injuries); and bicyclists without injuries to the abdomen or pelvis. Minor abdominal or pelvic injuries were excluded because they would not likely result in hospitalization in and of themselves. Using US census data, national estimates of handlebar-related abdominal and pelvic organ injury incidence data for the 19 states were extrapolated to the age-specific US population to determine national estimates. The proportion of injuries associated with handlebars was derived by multiplying national estimates of the number of non–motor vehicle bicycle crashes associated with abdominal or pelvic organ injuries times the proportion of these injuries associated with handlebars, as determined by the medical record review at CHOP.

ECONOMIC ANALYSES

In addition to the incidence of handlebar-related injury, the outcome measures in this study included lifetime medical costs, lifetime productivity loss, and lifetime monetized quality-adjusted life-years (QALYs). (See **Table 1** for factors used in derivation of costs.) The costs per injury used have appeared in several other studies.[23-25]

As recommended by the Panel on Cost-Effectiveness in Health and Medicine,[26] we report the present value of future costs computed at a 3% discount rate and adopt a societal perspective that includes all costs associated with unintentional injuries—costs to victims, families, government, insurers, and taxpayers. The incidence-based costs reported estimate the present value of all expected costs over the child's expected life span. For costs that will occur in future years, the present value is estimated, defined as the amount one would have to invest today to pay these costs when they come due. Costs were not assigned to duplicated medical records, readmissions, or fatalities. Cost was estimated in 1996 dollars separately for medical and other direct costs and for quality of life loss.[26]

Medical Charges and Costs

Hospital charges were taken directly from discharge records. Because hospitals negotiate payments with third-party payers, these charges were rarely paid in full, nor do they reflect actual costs. Medical costs of hospital-admitted injury survivors had 3 major components. The first was inpatient cost, including professional fees, which depends on length of stay in the hospital. The second included ambulance, ancillary, and post-discharge costs, such as prescriptions and follow-up medical care. The third component was the cost of processing health insurance claims, which depends on the primary payer.

Inpatient costs were taken from hospital discharge data files from New York (1994) and Maryland (1994-1995), the only states in which cost-control commissions required hospitals to report their costs per patient publicly and accurately.

Table 1. Factors for Economic Analyses*

Factor	Value	Source
Incidence	588 Nonfatal hospital admissions	19-State hospital discharge data
Age at onset, y	11.4 (12) [3-19]	19-State hospital discharge data
Hospital length of stay, d	5.0 (4) [1-34]	19-State hospital discharge data
Maximum Abbreviated Injury Score	2.7 (2) [1-5]	19-State hospital discharge data and ICDMAP-90 (Tri-Analytics, Inc, Bel Air, Md)
Case fatality ratio	1 Death per 589 admissions	19-State hospital discharge data
Medical cost, $	11 410 [1853 -74 487]	Maryland and New York hospital discharge data
Lost productivity cost, $	16 059 [11 745-14 964]	National Health Interview Survey and Bureau of Labor Statistics
Monetized quality-adjusted life-years lost, $	473 110 [60 161-628 754]	*Databook on Nonfatal Injury*[28]
Discount rate, %	3	Panel on Cost-Effectiveness in Health and Medicine

*Data are given as mean (median) [range] unless otherwise indicated.

The costs were adjusted from state to national price levels using 1994 American Hospital Association data on mean hospital costs per day by state.[27]

Professional fees were factored in using a ratio of professional fees to hospital payments computed from aggregate 1992-1994 Civilian Health and Medical Program of the Uniformed Services data. Diagnosis-specific regression models were then developed to separate the costs of injuries into a fixed cost per admission and a variable cost per day. These models were used in conjunction with the actual length of stay to compute a cost estimate for each acute injury admission in the 19-state hospital data. Subsequent visits to the hospital for the same injury were accounted for by multiplying the cost per admission times an estimate of admissions per victim derived from 1994 Missouri hospital discharge data by principal injury diagnosis.

Ambulance, ancillary, and postdischarge costs during the first 6 months after the injury were taken from the National Medical Expenditures Survey.[28] These factors were computed as a percentage of hospital costs for all injuries. Miller et al[28] developed diagnosis-specific ratios of 6-month to lifetime costs for injured workers. By diagnosis, the ratios of follow-up and longer-term care were adjusted to child-specific treatment and recovery patterns using 3 years of private health insurance claims data from Medstat Systems Inc, Fridley, Minn.[24] The adjusted ratios were used to extrapolate from the 6-month medical costs to lifetime costs.

Finally, medical costs accounted for health insurance claims processing costs. The ratio of claims processing costs to total claims, which varies by payer, was derived from insurance statistics.[29] These ratios were weighted by the distribution of payers to compute overall claims processing cost percentages by diagnosis. The payer distributions were derived from the National Hospital Discharge Survey. Total medical costs were then inflated from 1994 to 1996 dollars using an index of medical expenditures per capita.[30]

Lost Work

Work loss included losses by victims and unpaid caregivers. Our estimation of victim costs differentiated between short-term work loss and long-term loss due to permanent work-related disability. Although young children do not lose work as a result of their injuries, we assumed that a parent or other adult caregiver must lose work to care for the child. In addition, we assumed that children who are permanently disabled have reduced work capacity as adults. Short-term work loss of victims consisted of 2 groups of multiplicative factors: (1) the number of lost days of wage work and household work and (2) the loss per day for each of these categories. All computations were done by injury diagnosis. For injuries to subjects younger than 16 years, these calculations applied to the adult caregiver, who was assumed to lose a day's work when comparable injury to an adult would have resulted in a lost work day.

Detailed information was available about short-term work loss days. The number of work days an injury survivor or caregiver loses in the short term was computed by diagnosis from 1987-1993 National Health Interview Survey data on the probability that a worker will lose work when injured and from 1993 Bureau of Labor Statistics data on the mean days lost when an occupational injury causes work loss. Lost household workdays were based on information showing that workers who have only short-term disability return to household work 10% faster than those who return to wage work.[29] The National Health Interview Survey and Bureau of Labor Statistics data guided development of analytic estimates for the other categories. A key assumption underlying the estimates is that a given injury costs the victim or caregiver the same number of days of ability to work, whether or not the victim or caregiver is employed.

Days of lost ability to work were valued using the method recommended by the Panel on Cost-Effectiveness in Health and Medicine.[26] The panel suggested valuing a day of lost wage work from published national statistics about the wage and fringe benefit loss per day of wage work by age and sex. Household work loss per day by age and sex was taken from a published survey analysis.[28] That analysis considered household work hours per day, the distribution of hours among tasks (eg, cooking and yard work), and wage data by occupation.

Permanent work-related disability probabilities and the percentage of lifetime earning capacity lost to permanent disability were derived from a large national sample of worker injuries.[31] Permanent disability was valued as a percentage of the expected value of lifetime work. That value was the sum of the discounted present value, less lost capacity due to the injury, of expected earnings and household work by age and sex across the victim's remaining life span.

Lost Quality of Life

The largest cost of injury is generally the pain, suffering, and lost quality of life experienced by victims and their families. For fatalities, the QALYs equal the years of expected life lost discounted to present value. For nonfatal injuries, we used diagnosis-specific QALY estimates from the *Databook on Nonfatal Injury*.[28] Those estimates were computed in 3 steps. First, physicians rated the typical observable losses over time for victims of every injury diagnosis cataloged in a common diagnosis system.[28] The ratings covered 6 dimensions: bending, grasping, and lifting; cognitive; mobility; sensory; cosmetic; and pain. Second, data were added about the probability of permanent work-related disability by diagnosis. Third, with values for different functional losses from surveys of the general population,[32,33] the observable losses were converted into an estimated percentage loss in quality of life measured on a QALY scale. The surveys met the criteria subsequently established by the Panel on Cost-Effectiveness in Health and Medicine: they were preference-based and assigned scores of 0 to death and 1 to perfect health.

To put quality of life in terms that are comparable to other costs, we translated the QALY estimates into dollars. A value of statistical life (VSL), defined as the amount many people collectively spend on risk reduction in the expectation of saving 1 life (eg, how much 10 000 people spent or would be willing to spend for a 1 in 10 000 reduction in their risk of death), was chosen. For consistency with other studies, we used a conservative VSL of $3 million, which is consistent with findings on how much people are willing to pay to reduce their risk of death. This VSL was derived from more than 50 sound studies that used survey methods or analyzed what people routinely pay for small risk reductions—eg, the price of car safety features or the extra wages that must be paid to induce workers to take risky jobs.[34,35] Two meta-analyses suggested a VSL range of $1.5 to $4.5 million,[34,35] while less critical literature reviews suggested a $3 to $7 million range.[36,37]

The value of the loss of 1 QALY was then estimated from the VSL, based on economic theory.[25,38,39] Specifically, we subtracted lifetime work loss from the VSL to avoid double-counting and then divided the remainder by the expected years of life remaining at the time of the QALY loss, discounted to present value. With our VSL, the value per QALY is $97 200. Validation of this QALY estimate has been modest. Several studies[35,40-42] showed that the pain and suffering component of jury verdicts can be predicted from the QALY losses ($r^2>0.5$), with juries valuing QALYs consistent with a VSL of $1.7 to $4 million. Therefore, QALY costs reflect real and tangible losses.

RESULTS

19-STATE HOSPITAL DISCHARGE DATA FOR 1997

In 1997, 7148 subjects younger than 20 years were discharged from hospitals in the 19 states with any bicycle-related injury, and 668 (9.3%) of these sustained an AIS score of 2 or greater abdominal or pelvic organ injury. Among the children with serious abdominal or pelvic organ injury, 588 (88.0%) were injured in bicycle crashes not involving motor vehicles.

Among the latter group, the focus of this study (**Table 2**), 506 (86.1%) were male and 441 (75%) were white. Ages were distributed as follows: 13 (2.2%) younger than 5 years, 171 (29.1%) aged 5 to 9 years, 291 (49.5%) aged 10 to 14 years, and 113 (19.2%) aged 15 to 19 years. Abbreviated Injury Scale scores among the 588 cases were as follows: 407 (69.2%) AIS 2, 30 (5.1%) AIS 3, 59 (10.0%) AIS 4, and 92 (15.6%) AIS 5.

1996 THROUGH 2000 CHOP TRAUMA REGISTRY

Between January 1, 1996, and December 31, 2000, 444 pediatric patients were identified through the CHOP trauma registry with a bicycle-related injury. Fifty-six child bicyclists were admitted to CHOP for treatment of abdominal or pelvic organ injuries with AIS scores of 2 or greater, with 44 (78.6%) of these injured in bicycle crashes not involving motor vehicles. Handlebars were unequivocally documented as impacting the abdomen in 34 (77.3%) of the 44 non–motor vehicle crashes. In the remaining 10 cases, there were 4 in which handlebars were mentioned (eg, "flew over handlebars"), but no clear abdominal impact could be substantiated. Handlebar involvement could not be demonstrated in any of the motor vehicle–related crashes associated with abdominal or pelvic injury. Abbreviated Injury Scale scores among the 34 cases were distributed as follows: 8 (23.5%) AIS 2, 16 (47.1%) AIS 3, 8 (23.5%) AIS 4, and 2 (5.9%) AIS 5.

Table 2. Costs and Hospital Lengths of Stay for 588 AIS ≥2 Abdominal and Pelvic Organ Injuries From 1997 19-State Hospital Discharge Data*

Factor	Mean (Median) [SD]	Total
Hospital charges	11 840 (8721) [10 737]	6 393 609
Lifetime medical cost	11 315 (9265) [8940]	6 653 291
Lifetime productivity cost	13 014 (12 024) [19 255]	7 652 429
Lifetime monetized quality-adjusted life-years	568 719 (578 422) [104 366]	334 406 485
Hospital length of stay, d	5.0 (4.0) [4.0]	2916

*Monetary estimates are in 1996 dollars unless otherwise indicated. AIS indicates Abbreviated Injury Scale.

NATIONAL ESTIMATES FOR INJURY INCIDENCE AND COSTS

We estimated that, in 1997 in the United States, 1147 subjects (95% confidence interval, 1082-1215; 1.49 per 100 000 subjects 19 years and younger) had serious non–motor vehicle bicycle-related abdominal or pelvic organ injury leading to hospitalization, and 886 (95% confidence interval, 828-944; 1.15 per 100 000 subjects 19 years and younger) of these injuries may have been associated with handlebars. Hospital charges resulting from these injuries totaled $9.6 million, while costs came to $523.9 million. Children's handlebar-related injuries in 1997 caused $10.0 million in lifetime medical costs, $11.5 million in lifetime productivity losses, and $503.9 million in total lifetime monetized QALYs.

COMMENT

To our knowledge, this study provides the first national estimates of the incidence and cost of handlebar-related abdominal and pelvic organ injuries. In 1997 in the United States, nearly 900 subjects younger than 20 years had abdominal or pelvic organ injury associated with handlebars, resulting in nearly $10 million in direct hospital charges alone. These estimates indicate that handlebar-related injuries pose a serious health risk to children at a substantial health care cost.

Our results likely underestimate the incidence and cost of handlebar-related injuries. We focused on handlebar-related injuries in crashes not involving motor vehicles. The injury event in the case of a motor vehicle and bicycle crash is complex, and the handlebar component is typically overlooked or underappreciated. In addition, increasing numbers of children are riding other devices with handlebars, such as scooters, further suggesting that our estimates understate the incidence and cost of pediatric handlebar-related injuries. Also, child bicyclists were the focus of this article because they are most at risk for handlebar-related injuries. Adults, however, have injuries from handlebars, as well. Therefore, safer handlebars would be advantageous for all bicyclists.

Other groups have begun to highlight abdominal organ injury from handlebars. The Canadian Hospital Injury Reporting and Prevention Program, an emergency department–based injury surveillance program of 10 pediatric hospitals and 5 general hospitals, reported on the incidence of handlebar-related abdominal injuries.[43] Although only 30% of all pediatric bicycle handlebar-associated injuries (all severities, including minor AIS 1 injuries) were to the abdomen or pelvis, 76% of the child handlebar-related hospitalizations were because of abdominal or pelvic injuries. Furthermore, recent data from the Canadian Hospital Injury Reporting and Prevention Program (through March 31, 2001) indicate that 70% of abdominal injuries of all severities to child bicyclists were suspected or definitely associated with handlebars and that 99% of handlebar-associated abdominal injuries were in crashes not involving motor vehicles (Steven McFaull, MSc, written communication, April 26, 2001). These data corroborate our findings that handlebar impacts are likely associated with abdominal organ injury and that most handlebar-associated injuries occur in bicycle crashes not involving motor vehicles.

Although most abdominal and pelvic organ injuries in children can be managed nonoperatively, the cost nonetheless can be high. Clarnette and Beasley[5] noted a solid organ injury (ie, an injury to the liver, spleen, pancreas, or kidney) in 62.5% and a hollow organ injury (ie, an injury to the intestines, stomach, or bladder) in 12.5% of children with a handlebar injury at their center. Patients with a solid organ injury typically require an inpatient hospital stay of 4 to 6 days, including a mean of 1 day in the intensive care unit.[44] In addition, significant laboratory and radiological charges are incurred as a part of the evaluation and subsequent monitoring of the physiologic response to the injury. Patients with a hollow organ injury (7% of CHOP patients with abdominal or pelvic organ injuries with AIS scores of ≥ 2), such as a duodenal hematoma or intestinal perforation, have a significantly longer hospital course. Children sustaining a hollow organ perforation required a mean hospital stay of 8.7 to 9.2 days, including an operation in all cases.[45] Children sustaining blunt, nonperforating intestinal injury (duodenal hematoma) often had hospital stays exceeding 2 weeks (range, 3-47 days).[46]

LIMITATIONS

This analysis required using 2 data sources to determine handlebar involvement: a large hospital discharge data set from 19 states, extrapolated using US Census data to generate national estimates of abdominal and pelvic injuries, and a trauma registry with detailed medical records at a pediatric trauma center. The CHOP population had a distribution of abdominal organ injury severity that was somewhat higher than that of the 19-state population. Because our extrapolations assumed that the distribution of bicycle handlebar-related injuries in the hospital-verified population did not vary by AIS score (the actual differences in handlebar relatedness by AIS score were 66.7% AIS 2, 88.9% AIS 3, and 71.4% AIS 4-5), the estimates would have been 10.8% lower if the extrapolation by AIS had been stratified. On the other hand, the populations were compared according to other factors and were comparable with respect to hospitalizations for child bicyclist abdominal and pelvic organ injury, as evidenced by similar distributions of abdominal and pelvic organ injuries among child bicyclists (19-state database, 9.3%; CHOP trauma registry, 12.6%) and by similar relationships between non–motor vehicle child bicyclist crashes and abdominal and pelvic organ injuries (19-state database, 88.0%; CHOP trauma registry, 78.5%). Because of these small differences, the extrapolation to generate useful national estimates seems reasonable.

We did not use the US Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) to generate national estimates of handlebar-related injuries, because we did not believe that this method would produce reliable results. Although CHOP is a NEISS site, a review of 5 years' worth of data revealed that none of the handlebar-related injuries treated at CHOP were included in NEISS. This discrepancy is likely explained because diagnoses in NEISS are based on those recorded in the emergency department record alone (without review of the inpatient record), which would likely not include the definitive diagnosis. The definitive diagnosis of organ damage is often made with subsequent diagnostic testing conducted after hospital admission.

Although more than 90% of cases of pediatric injury in the 19-state hospital discharge data set contained E-codes, these data are subject to little, if any, validation and quality control in most states. As a result, there might have been some misclassification of E-codes.

The reliability of the extrapolation to national estimates from the 19 states depends on the similarity between the 52% of the population covered and the population in the rest of the country. Although essentially a convenience sample, it was a large sample, and distributions would have to vary substantially in the other states to change the estimates to any significant degree. The sample evaluated included large populations from all regions of the country. In addition, many of the large-population states contain extensive rural and urban areas. To compare the similarity of the burden of age-specific bicycle injuries in the surveyed states vs the nonsurveyed states, we calculated the 3-year (1996-1998) mortality rates for bicycle crashes with and without motor vehicle involvement for subjects 19 years and younger in both groups. The bicycle motor vehicle–related fatality rates were 0.35 and 0.33 per million population in the 19-state sample and in all other states, respectively.[47] The fatality rate unrelated to motor vehicle involvement was 0.03 per million population in the 19-state sample and in all other states. Given that the 19-state bicycle-related age-specific mortality rates are similar to the national rates, the 19-state morbidity sample was probably similar to the rest of the states that were not included in the hospital discharge sample.

Identification of the handlebar as causative in abdominal and pelvic organ injury was based on review of the hospital medical records of children identified through the CHOP trauma registry. A case was listed as handlebar-related if specific mention was made of the handlebar in the medical record. This likely represents an underestimate, as those cases in which the handlebar was causative but not indicated in the medical record would not be captured. The reliance of the extrapolation of handlebar relatedness from one trauma center is also a limitation. However, we found in a large state in which trauma center designation was included in the hospital discharge data that two thirds of all cases of hospitalized bicycle injuries in children with abdominal or pelvic AIS scores greater than 1 were taken to a trauma center.

Although the large 19-state hospital discharge database was used to generate national estimates of injuries, the data sets used in the cost estimates had several inherent biases. Although the permanent disability cost estimates associated with productivity losses take into account the longer life span of children, the cost estimates are not child-specific in all respects. In particular, the costs do not reflect parental productivity losses amassed in the long-term care of the permanently disabled child. Furthermore, because children's earnings are in the future, their present value also is less than the present value of earnings losses of young adults, even though more years of future work are lost. Some of the minor cost contributors in this analysis also have limitations, because data used to estimate them are 10 to 15 years old. Inflating these old estimates to current dollars may introduce some inaccuracy, but they contribute too little to total costs to justify the expense of collecting new estimates.

Societal cost estimates that include monetized QALYs cannot be compared with most other estimates that do not use them. Policy choices could be distorted when analysts who choose to do so can, at will, inflate the costs of the condition they are studying by adding in the monetized QALYs. Resources would be preferentially allocated toward effective interventions that had the good fortune to be assessed by an analyst choosing to express matters in terms of dollar costs and benefits including monetized QALYs. Without QALY monetization, children's handlebar-related injuries would cost $21 million and 5000 QALYs (a life-year loss equivalent to 175 child deaths) in 1997. To offer a fair comparison including monetized QALYs, unintentional firearm injuries of subjects 14 years and younger cost $3.85 billion annually[48]—about 7.5 times the cost of handlebar-related injuries.

PREVENTION IMPLICATIONS

Handlebar-related organ injury largely occurs in minor, non–motor vehicle–involved events that should cause little more than a bruise or abrasion. Unfortunately, safety improvements to reduce morbidity associated with handlebar injuries have been slow in coming, even though the risk to child bicyclists of handlebar impacts has been known for more than 30 years. When products, such as handlebars, continue to cause significant morbidity and mortality, voluntary or mandatory standards may be needed. Product modifications offer a potential for the reduction in frequency and severity of handlebar-related injuries and may therefore address one mechanism of bicycle-related injuries in childhood.

Manufacturers have long worked to improve the safety of bicycles by imposing and following design and safety standards. These standards, however, do not cover impact attenuation of handlebars. Many bicycles for young riders have handlebars that are small in diameter, and the small diameter of the impacting surface causes a greater concentration of the forces on the body surface (Mark Pozzi, MS, written communication, April 16, 2001). This places children at increased danger of serious abdominal and pelvic injuries. As has been demonstrated in actual crashes,[19] the handlebar ends can act as blunt-ended spears, causing intra-abdominal and pelvic organ damage. Furthermore, typical bicycle handlebars are formed from steel or aluminum tubing, and most have no mechanical means for securing bar end plugs or caps. As a result, handlebar ends can become uncovered during a crash and expose the rider's body to bare metal, resulting in serious puncture wounds.

In addition, bicycles demonstrate a range of safety hazards related to the handlebar stems and gearshift levers mounted on the handlebars. Most inexpensive bicycles use handlebar stems with projecting bolt heads and gearshift levers mounted at the top of the stem. Although this location is less expensive for the manufacturers, because it reduces the length of control cables and number of parts required, it presents a serious injury hazard to the rider. Because of the protrusion of the gearshift levers, there is a serious potential for concentrations of injury-producing force on an exposed body during a crash, especially if the gearshift levers are pointed directly rearward at the instant of contact. However, there are more expensive, higher quality, multispeed bicycles in which manufacturers have located the gearshift levers on the frame's down tube, decreasing the likelihood of injury during a crash. Through consumer awareness, existing technology for handlebars, and potential new design,[20] safer handlebars can be manufactured.

Clinicians can play an important role in the prevention and treatment of handlebar-related injuries. Through anticipatory guidance, clinicians can educate parents about choosing and maintaining their child's bicycle. This education might include proper sizing of the bicycle to the child, appropriate type of bicycle for the child's age and skill level, maintenance of the bicycle to prevent mechanical failure, and maintenance of handlebar guards. If a child bicyclist is injured in a fall, clinicians should elicit a complete trauma history from emergency medical services personnel, children, and witnesses. Identi-

What This Study Adds

This study provides the first national estimates of the incidence and cost of handlebar-related abdominal and pelvic organ injuries. It presents evidence that handlebar-related injuries pose a serious health risk to children and result in substantial health care costs. Requirements for safer handlebar designs may provide one avenue to achieve a health and economic benefit.

fication of handlebar impact may be essential to identifying serious occult truncal injuries in child bicyclists.

This article demonstrates a substantial cost associated with preventable, handlebar-related injuries. Safer handlebar designs that dissipate the impact force and distribute the force over a broader surface area are feasible and could potentially minimize the risk of handlebar-related injuries.[20] The knowledge that potential solutions exist and awareness of the substantial cost of handlebar-related injuries should prompt discussion of feasibility of requiring safer handlebars on all bicycles.

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Dr Winston has a patent pending for a new handlebar design.

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