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Economic Evaluation of Concussion Programs in the State of Idaho: The Collective Potential of Prevention and Clinical Care

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Abstract

Concussion, or mild traumatic brain injury especially among young children, teenagers, and young adults, is a significant problem in Ada County, Idaho, and the United States. Although much has been learned about concussion, considerable controversy and gaps in knowledge still exist in many areas of research, leading to variation in concussion assessment, treatment and management protocols. Health systems can positively impact concussion outcomes through community education and outreach, and provision of timely, coordinated, evidence-based clinical care. Collectively, these measures serve to reduce concussion incidence (primary prevention), enable more timely recognition of concussion by parents, coaches, and teachers of youth athletes (secondary prevention), and improve treatment of concussion after it has occurred (tertiary prevention). Using the concussion prevention and clinical care coordination activities of St. Luke's Health System in Idaho as a benchmark, this analysis estimates the economic value of these preventive measures, in particular those preventive measures that target pediatric population, for Ada County and the state of Idaho, and includes both year of injury and long-term costs of concussion. This study adopts a societal perspective, incorporating savings in direct medical, indirect, and quality of life costs.

Keywords: care coordination, economic impact, concussion, traumatic brain injury, cost of illness, quality of life

Conflict of Interest/Funding Declaration

This study is funded entirely by St. Luke's Health System (SLHS). Primary author Susie Bergeron is an independent health economics consultant hired by SLHS to perform economic valuations of health initiatives. Dr. Hilary Flint is employed by SLHS as Director of its Applied Research Division (ARD). Dr. Zeynep Hansen was the Chair of the Department of Economics during this study and is a Professor of Economics at Boise State University and serves as a volunteer health economics consultant to SLHS.

Introduction

Concussion, or mild traumatic brain injury (mTBI), is a significant problem in Ada County, Idaho, and the U.S. Although much has been learned about concussion, considerable controversy and gaps in knowledge still exist in many areas of research, leading to variation in concussion assessment, treatment and management protocols. There are also substantial gaps in knowledge of long-term health impacts of concussion.

Concussion incidence is difficult to estimate, as many people with concussion do not present for medical treatment. Further, many patients who present to the emergency department (ED) with possible traumatic brain injury (TBI) are not diagnosed with TBI because of limited sensitivity of standard clinical interviews and computed tomography (CT) scans in diagnosing TBI.[1] However, the reported incidence rate of concussion has been climbing sharply in recent years.[2] Increased public awareness of the dangers of concussion, coupled with legislation regarding return-to-play (RTP) standards, have possibly led to a higher proportion of people with concussion presenting for treatment. Populations at highest risk of concussion are children 4 years of age and younger, teenagers aged 15-19 years, and people over the age of 75 years.[3]

Health outcomes vary significantly among those impacted by concussion. Although many patients may make a full recovery, some people with concussions have difficulty returning to routine daily activities and may be unable to return to work for weeks or months. Some concussion patients suffer from various neurological and psychiatric sequelae that impair health and well-being for many years. Costs associated with medical care, lowered productivity, and diminished quality of life (QOL) for this "miserable minority" are substantial.[3]

Links between concussion and various chronic diseases have been proposed, but more studies are needed to establish causality. For example, links between concussion and attention deficit hyperactivity disorder (ADHD), Parkinson's Disease (PD), and Alzheimer's Disease (AD) have been established, but the direction of causality is unclear and more research is needed.[4] Several studies indicate probable causal links between concussion and depression, headache, and epilepsy.[5-8]

Health systems can positively impact concussion outcomes through community education and outreach, and provision of timely, coordinated, evidence-based clinical care. Collectively, these measures serve to reduce concussion incidence (primary prevention), enable more timely recognition of concussion by parents, coaches, and teachers of youth athletes (secondary prevention), and improve treatment of concussion after it has occurred (tertiary prevention). Research studies aimed at understanding injuries leading to concussion, brain effect of concussion, and QOL following concussion support and enhance these measures. This analysis estimates the economic value of these preventive measures for Ada County and the state of Idaho, and incorporates both year of injury and long-term costs of concussion.

METHODS

Programs

St. Luke's Health System, (SLHS) provides primary concussion prevention programs aimed at reducing concussion in youth athletes around the state of Idaho. In 2015, the St. Luke's Concussion Clinic provided direct concussion education to over 4000 youth sport coaches, parents and athletes, promoted concussion awareness and prevention at numerous health fairs, conferences and other public events, drafted concussion management protocols for 17 school districts, clubs, and city recreation departments, and worked with the Centers for Disease Control and Prevention (CDC) and the MacNeil/Lehrer Foundation to create and pilot the first U.S. concussion education curriculum to 8th and 9th grade students in two Idaho school districts. This work supports Idaho law (Section 33-1625) passed in 2012 requiring school districts to educate parents and guardians regarding the signs, symptoms, nature, and risks of concussion and head injury, to remove youth athletes from play when concussion is suspected, and to require approval from a medical practitioner before allowing youth athletes to RTP.[9]

Beginning in the 2016-2017 school year, the Idaho High School Activities Association required all coaches to review a concussion education training video created by the St. Luke's Concussion Clinic. In another community/SLHS partnership, ski patrol at three Idaho ski areas now utilize the Ski Injury Prevention App which assesses concussions, among other injuries.

Secondary and tertiary prevention is provided through timely, coordinated concussion care at the St. Luke's Concussion Clinic, a virtual clinic under the leadership of medical director Kurt Nilsson, MD. By providing a central access point to health care systems and preliminary phone assessment, concussion patients receive more timely, appropriate and cost-effective care. Use of up-to-date clinical decision rules regarding computed tomography (CT) scans after concussion, and patient education and support from concussion care coordinators further support cost-effectiveness of concussion care.

Literature Review

Because of the broad scope of this analysis, the study team relies on data and estimates found in peer-reviewed journal publications on the prevention of concussion and effects of concussion care coordination. To obtain data and estimates for our meta-analysis, we searched Medline and Academic Source Premier using search terms of *concussion, mild traumatic brain injury, interventions, post-concussion syndrome, headache, migraine, epilepsy, major depressive disorder (MDD), depression, AD, PD, ADHD, cost of illness, disability weights,* and *care coordination*. This information is used to estimate costs associated with concussion, quantify the cost saving effects of coordinated concussion care, and identify causal links between concussion and long-term sequelae.

Year-of-injury cost data were obtained for treatment of concussion in pediatric populations because most TBI occurs in the population aged 19 and below,[10] and the primary prevention activities of SLHS target youth athletes. There is a paucity of research on long-term effects and costs of concussion; however, the literature review revealed possible causal links between concussion and MDD, headache, and epilepsy. Accordingly, these three conditions are included as long-term sequelae of concussion in this analysis. There are probable causal links between concussion and several types of headache; however, migraine is the most common headache type associated with concussion.[11] This analysis assumes that all concussion-related headache is migraine.

Analytic Framework for Economic Evaluation

This analysis focuses on providing an estimate for the value of primary, secondary, and tertiary prevention measures provided by SLHS in Idaho. Primary prevention activities of community outreach and education provided by SLHS potentially benefit all residents of Idaho regardless of healthcare provider. In addition, the St. Luke's Concussion Clinic furthers secondary and tertiary prevention by providing timely and appropriate care to concussion patients presenting for care at SLHS. This analysis assumes similar concussion care from other Idaho healthcare providers is available to the population in Ada County and Idaho.

Cost savings are achieved in two ways: through primary prevention measures that reduce concussion incidence, and through secondary and tertiary prevention measures that lower cost per concussion patient. Because of the on-going nature of efforts to prevent and treat concussion, results are given in terms of expected annual savings, which is the sum of cost-savings from primary concussion prevention, $S_{p,}$ and improved care coordination (secondary and tertiary prevention), S_t:

$$\text{Annual savings} = S_p + S_t$$

This analysis adopts a societal perspective, incorporating savings in direct medical, indirect, and QOL costs and giving results for Ada County and the state of Idaho. Indirect costs include costs associated with missed work and lowered productivity. QOL costs are monetized by multiplying applicable disability weights by the generally accepted standard of $50,000 per disability-adjusted-life-year. S_p and S_t are each comprised of savings in direct medical, indirect and QOL costs. All costs are adjusted for Idaho cost of living index[12] and medical and general inflation[13] to 2016 dollars.

Program Benefits from Primary Prevention: Costs Averted by Reducing Concussions

To estimate $S_{p,}$ annual savings from primary concussion prevention, annual number of averted concussions was multiplied by per person expected lifetime cost of concussion. Estimating annual number of averted concussions required a baseline concussion incidence rate and projected reductions in incidence. Because of the wide variety of people affected by concussion prevention and care, this analysis employs the national incidence rate of concussion given by theCDC and does not utilize concussion incidence rates for individual sports. The CDC estimates the incidence of traumatic brain injury to be 823.7/100,000 persons and states that 75% of TBI is mTBI; this yields an mTBI incidence of 617.8/100,000 persons.[14] The proportion of TBI cases classified as mTBI and the resulting incidence rate of mTBI is roughly consistent with, though more conservative than, the rate calculated in a recent study by Korley et al.,. Analyzing data from the National Hospital Ambulatory Medical Care Survey of ED visits in 2009 and 2010, the study found that among ED visits for which a Glasgow Coma Scale score was documented, 94.5% of cases were classified as mTBI.[1]

Though there are subtle differences in the definitions of concussion and mTBI, this analysis employs the mTBI incidence rate as the concussion incidence rate and assumes the population in Idaho and Ada County is similar to the U.S. averages; thus, the study team applied CDC estimates of incidence rates for TBI and mTBI for the state and the county. Baseline numbers of concussions were calculated by multiplying U.S. Census population statistics for Ada County and the state of Idaho (444,028 and 1,683,140 respectively) by CDC estimates of concussion incidence. The team estimates baseline number of annual concussions to be 2743 and 10,398 for Ada County and the state of Idaho respectively. Because of the broad range of concussion prevention programs examined in this analysis, estimates of averted concussions and associated cost savings are presented with projected reductions in concussion incidence of 5, 10, and 20 percent after the implementation of concussion prevention programs. These projected reductions in concussion incidence are based on results achieved by the Heads Up to Youth Sports (HUYS) program of the CDC that has been shown to reduce concussion rates in youth football by up to 34%[15] and the relatively high representation of youth athletes among concussion victims.[16]

The expected lifetime cost of concussion figure has two components: year-of-injury costs and the present value (PV) of long-term costs associated with concussion sequelae of MDD, migraine headache, and epilepsy in years 1-30 after injury. Year-of-injury direct medical costs were estimated based on cost data from a recent study by Graves et al. of healthcare costs one year after pediatric TBI (n=308,174). Claims data were examined for enrollees in privately insured employer-sponsored heath plans with at least one TBI diagnosis. Total reimbursed costs included inpatient admission, inpatient services, and outpatient services costs.[17] To estimate year-of-injury costs attributable to mTBI, total healthcare costs in the six months prior to injury were annualized (doubled) and subtracted from total healthcare costs in the 12 months after injury.

To examine the costs of concussion requiring only outpatient care, the study team examined a study by Taylor et al. of outpatient costs in a large pediatric independent practice association in Massachusetts (n=75,683).[18] Total reimbursed costs include services for primary care provider visits, specialist visits including sports medicine, neurology, and neurosurgery encounters, ED visits, radiology procedures, and neuropsychological testing.

Year-of-injury indirect costs were estimated by totaling year-of-injury indirect costs of MDD, migraine headache, and epilepsy. Year-of-injury QOL costs were calculated using a concussion disability weight of 0.11.[19]

Long-term costs associated with long-term sequelae of concussion were calculated using an odds ratio (OR) for concussion and MDD of 1.77,[6] a relative risk (RR) ratio for concussion and headache of 1.70,[7] and an RR ratio for concussion and epilepsy of 1.51[5] identified from the literature review. To capture long-term costs, studies with longer-term time horizons (16 years for depression, and 10 years for epilepsy) were used. A study with a shorter time frame (< one year) and a pediatric population was used to obtain an RR of concussion and headache for reasons of conservatism.

Prevalence rates of long-term sequelae in the subpopulation with concussion exposure were calculated by multiplying prevalence rates for population unexposed to concussion (population prevalence adjusted for population attributable fraction of concussion) by applicable RR or OR. [(Population attributable fraction [PAF] calculated with formula [Pe(RR-1)]/Pe(RR-1)+1] where Pe=prevalence of concussion exposure. Population prevalence was multiplied by [1-PAF] to derive prevalence in population unexposed to concussion.) Prevalence rates for those unexposed to concussion were subtracted from prevalence rates for those exposed to calculate the risk difference. Direct medical costs, indirect costs, and disability weights for MDD, migraine headache, and epilepsy were identified by the literature review.[20-23] Long-term QOL costs for MDD, migraine headache, and epilepsy were calculated by multiplying disability weights of 0.145, 0.441, and 0.263 respectively[19] by $50,000. The disability weight associated with the least severe form of each sequela was used for reasons of conservatism. Expected values of concussion sequelae costs were calculated by multiplying the risk difference for each sequela by associated costs (this attributes a portion of population-level concussion sequelae costs to each person with concussion). PV of long-term concussion cost was calculated using a 30-year time horizon, discount rate of 3%, medical inflation rate of 3%, and general inflation rate of 2%. PVs of long-term costs of concussion sequelae were added to year-of-injury costs to calculate total expected cost per person with concussion.

To give an example using direct medical costs of MDD, we first multiplied MDD prevalence in the population unexposed to concussion, 5.6%,[24,25] by long-term RR of 1.77[6] to yield an MDD prevalence rate of 9.9% in the subpopulation exposed to concussion. Subtracting 5.6 from 9.9 gives a risk difference of 4.3%. We multiplied annual direct medical costs of MDD of $2233 [12,13,21] by risk difference of 4.3% to yield annual expected value of MDD-related direct medical costs of $113 per person exposed to concussion. The study team used Excel software (Microsft Corporation, Redmond, WA) to calculated the PV of annual costs of $113 growing at 3% annually over 30 years to yield $3395, the PV of MDD-related direct medical costs per person with concussion exposure (discount rate = 3%).

Program Benefits from Secondary and Tertiary Prevention: Lowered Cost per Patient

To estimate S_t, annual savings from secondary and tertiary prevention in the form of timely, coordinated clinical care, the study team multiplied baseline numbers of annual concussions for Ada County and the state of Idaho by year-of-injury cost reductions per concussion patient. These cost reduction estimates were based on studies of direct medical costs of concussion[17] and effectiveness of coordinated concussion care in improving cognitive functioning and emotional state in the months following concussion.

To estimate percentage savings in direct medical costs from improved care, this analysis uses cost data from Taylor et al.[18] That study showed direct medical cost savings of 31% from 2007 to 2013, thought to be related to larger percentages of concussion patients seen by primary care providers rather EDs, lower rates of CT scanning, and lower cost per cranial CT scan.[18] This analysis assumes that SLHS has realized similar cost savings and applies a 31% cost reduction to both outpatient and total direct medical costs of concussion adapted from Taylor et al.[18] and Graves et al.[17] respectively.

The analysis also assumes indirect and QOL cost savings from improvements in clinical care coordination as somatic symptoms, cognitive difficulties, and anxiety lessen with improved patient education and attention from caregivers.[26] A reduction of 15% in indirect and QOL costs was assumed based on results from an intervention study showing improvement in test scores measuring cognitive ability and emotional state of approximately 15% after the institution of patient education measures.[27] Indirect costs used incorporate year one costs of concussion sequelae of MDD, migraine, and epilepsy, and QOL costs are based on concussion disability weight of 0.11.[19] Per person cost savings from secondary and tertiary prevention were calculated by summing savings in per person direct medical, indirect, and QOL savings.

Total Program Benefits

Total program benefits were calculated by summing $S_{p,}$ cost savings from primary prevention (projected number of averted concussions * per person lifetime cost of concussion), and S_t, cost savings from secondary and tertiary prevention (baseline number of concussions * per person cost savings from clinical care coordination). Cost-savings from primary prevention, S_p, were calculated using the new, lowered per person costs of concussion after secondary and tertiary prevention measures to avoid double counting of cost savings.

Results

Cost Savings from Secondary and Tertiary Prevention

Secondary and tertiary prevention (concussion care coordination) outcomes are discussed first because the resulting cost figures are used in calculations of savings from primary prevention. Annual direct medical cost savings of $199 per person (outpatient) and $418 (total) reflect 31% cost reductions. Total per person year-of-injury cost-savings of $1272 represent an 18% savings from estimated per person year-of-injury costs of $7045 without improved care coordination. Table 1 delineates the calculations of annual per person cost savings from improved care coordination.[13,18,19,27]

Table 1. Estimated per person year-of-injury cost savings from care coordination, (2016 $, adjusted for Idaho cost of living)

Cost category	Costs without care coordination	Costs with care coordination*	Cost savings from care coordination
Total direct medical^	$1,349	$931	$418
*Outpatient costs only***	*$642*	*$443*	*$199*
Indirect^^	196	167	29
QOL***	5,500	4,675	825
Total costs^^^	$7,045	$5,773	$1,272

*Assumes 31% decrease in direct medical costs and 15% decrease in indirect and QOL costs
^Annual all-cause healthcare costs in 12 months following concussion less annualized healthcare costs from 6 months preceding concussion,
**Outpatient costs across all ambulatory care settings
^^Sum of estimated year one indirect costs from concussion sequelae of MDD, migraine, and epilepsy
***Baseline value is standard value of DALY of $50,000 multiplied by year one concussion disability weight of 0.11
^^^Sum of total direct medical, indirect, and QOL costs

Estimated cost savings for Ada County and state of Idaho from improved care coordination are substantial. Table 2 lists results by cost category (assumes baseline number of expect annual concussions).[28]

Table 2. Estimated Annual Savings from Timely, Coordinated Concussion Care, Ada County and State of Idaho, N=baseline expected number of annual concussions

Geographic area	Cost category	Calculation (N*per person cost savings)	Result
Ada County (N=2743)	Direct medical	2743*418	$1,146,574
	Indirect	2743*29	79,547
	Quality of life	2743*825	2,262,975
	Total	2743*1272	$3,489,096
State of Idaho (N=10,398)	Direct medical	10,398*418	$4,346,364
	Indirect	10,398*29	301,542
	Quality of life	10,398*825	8,578,350
	Total	10,398*1272	$13,226,256

Cost Savings from Primary Prevention

Primary prevention efforts of community outreach and education are projected to yield significant cost savings by lowering the incidence of concussion in Ada County and the state of Idaho. Calculations of savings from primary prevention required estimation of per person lifetime cost of concussion. This analysis estimates this cost at $43,338. Components of this figure are delineated in Table 3.

Table 3. Per person lifetime cost of concussion, 2016 $

	Direct medical	Indirect	QOL	Total
Year of injury	$931	$167	$4,675	$5,773
MDD	3,395	2,368	8,085	13,849
Migraine	3,455	2,145	14,082	19,681
Epilepsy	683	559	2,793	4,035
Total	$8,464	$5,238	$29,635	$43,338

Sensitivity analysis was performed to estimate population cost-savings resulting from lowered concussion incidence, giving cost-savings achieved by reductions of 5%, 10%, and 20% in the concussion incidence rate. These figures represent savings in lifetime concussion costs from concussions averted each year by primary prevention measures of community outreach and education. Projected cost savings from reductions in concussion incidence are given in Table 4, listing results for Ada County and the state of Idaho.

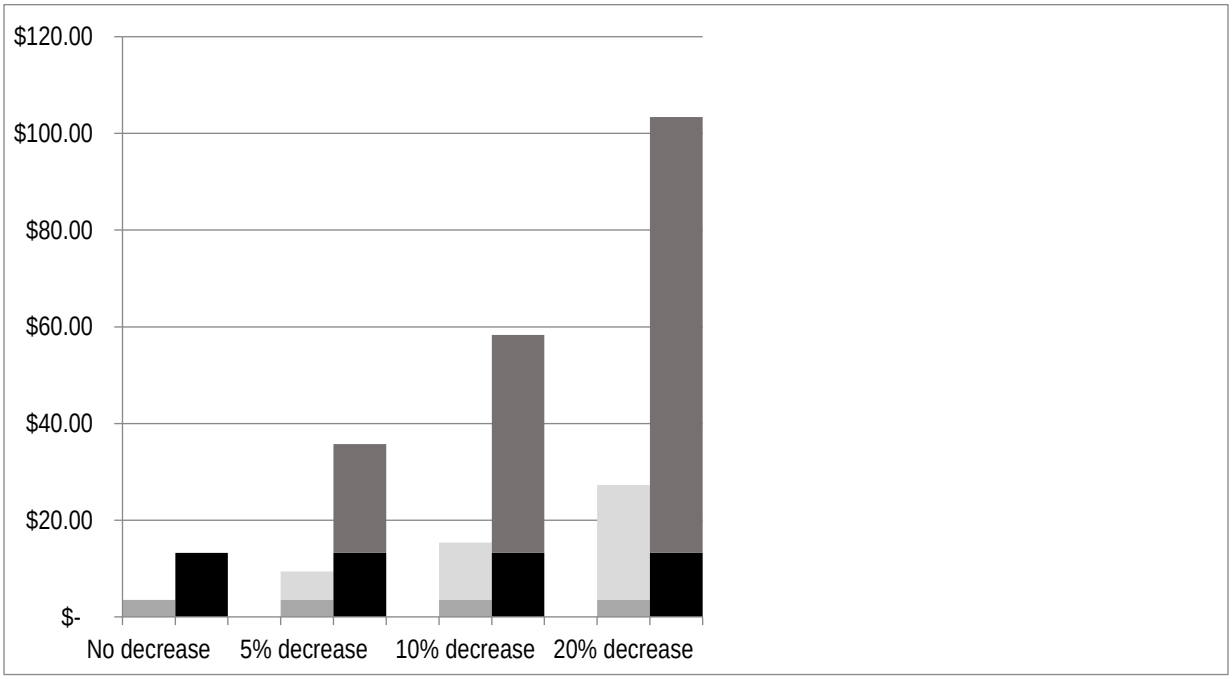
Table 4. Sensitivity Analysis, Annual Savings from Reduced Concussion Incidence, Ada County and State of Idaho (million 2016$)

Scenario	Number of concussions averted	Direct medical cost savings	Indirect cost savings	QOL cost savings	Total savings from reduced concussion incidence
Ada County annual savings (million 2016 $)					
5% reduction in concussion incidence	137	$1.16	$0.72	$4.06	$5.94
10% reduction in concussion incidence	274	$2.32	$1.44	$8.13	$11.89
20% reduction in concussion incidence	549	$4.64	$2.87	$16.26	$23.78
State of Idaho annual savings, (million 2016 $)					
5% reduction in concussion incidence	520	$4.40	$2.72	$15.41	$22.53
10% reduction in concussion incidence	1040	$8.80	$5.45	$30.82	$45.06
20% reduction in concussion incidence	2080	$17.60	$10.89	$61.63	$90.13

Total Cost Savings from Primary, Secondary, and Tertiary Prevention

Total projected cost savings from primary, secondary, and tertiary prevention measures are substantial. Figure 1 summarizes annual cost savings at projected reductions in concussion incidence of 0%, 5%, 10%, and 20% in Ada County and the state of Idaho, respectively. Assuming a 10% reduction in concussion incidence, total annual savings are estimated at $15.38 million and $58.30 million for Ada County and the state of Idaho, respectively.

Figure I. Projected annual cost savings from improved concussion care coordination and reduced concussion incidence for Ada County and state of Idaho at 0%, 5%, 10%, and 20% reductions in concussion incidence, million $ (2016)

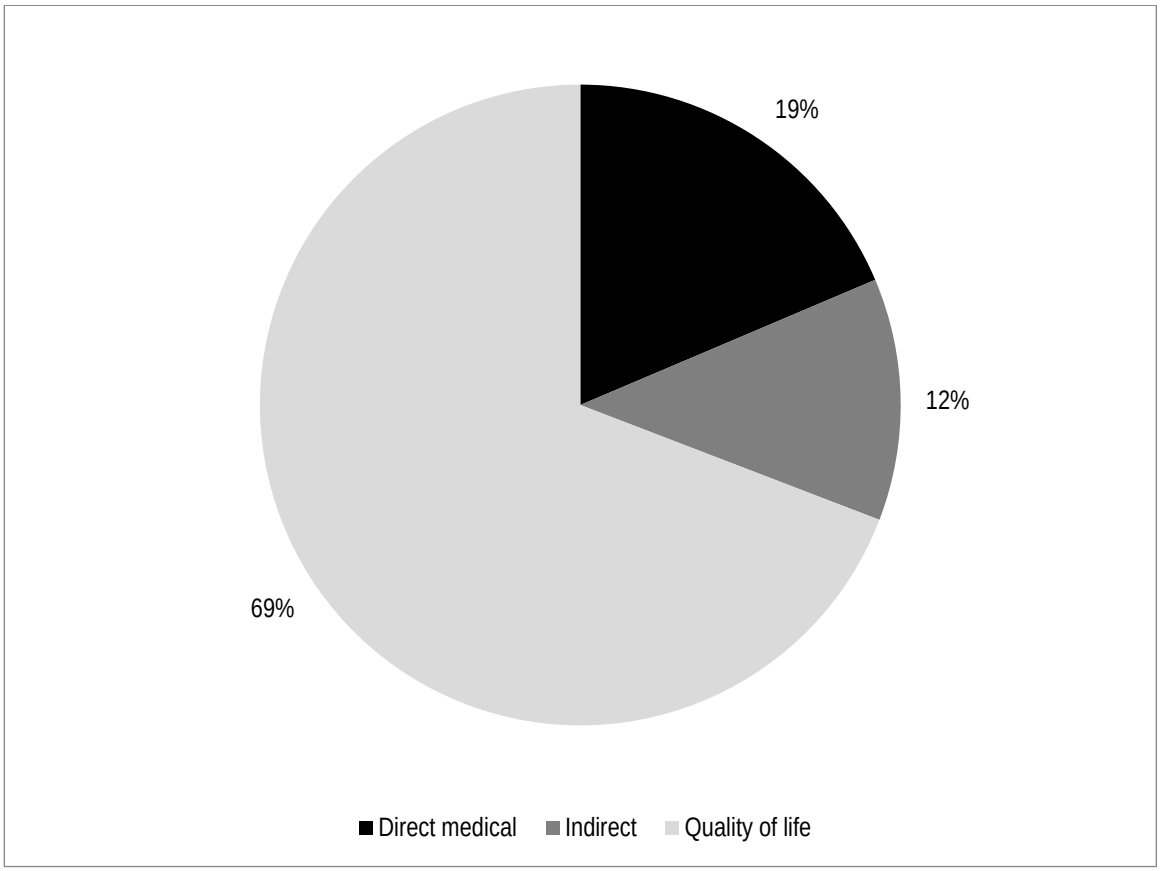


DISCUSSION

Concussion is a serious problem in Ada County and Idaho, leading to high costs in human and economic terms. Interventions that lower the incidence of concussion and improvements in treatment and management of concussion can improve health outcomes and lower the economic burden of concussion. This analysis estimates substantial cost savings from community outreach and education (primary prevention) and concussion care coordination (secondary and tertiary prevention) activities at SLHS.

While savings in direct medical and indirect costs are significant, QOL cost-savings make up the majority (two thirds) of estimated cost-savings. Disability weights for the mildest forms of MDD, migraine headache, and epilepsy were used in the calculations for conservatism; however, estimated QOL costs from concussion were still substantial due to the relatively large impact of these concussion sequelae on QOL. See Figure 2 for a breakdown of per person lifetime costs of concussion by cost category.

Figure II. Per person lifetime costs of concussion, percentage by cost category



Because of the high per person lifetime cost of concussion ($43,338), cost-savings from reduced concussion incidence are higher than cost-savings from concussion care coordination at all levels of concussion incidence reduction projected in the sensitivity analysis (5%,10%, and 20%). For example, at a 10% reduction in concussion incidence, 77% of total cost savings are due to reduced incidence. However, savings from care coordination are substantial. Annual savings from timely and appropriate care are estimated at $3.49 million and $13.23 million for Ada County and state of Idaho, respectively. Following is a discussion of SLHS programs that potentially create these economic benefits.

Community Outreach and Education

The concussion prevention activities of SLHS focus on lowering concussion incidence in youth athletes. Youth sports participants make up a critical population to target with concussion prevention initiatives, as lifetime costs of concussion can be substantial for this group. Prevention outreach provides needed education and awareness of concussion for parents, teachers, and coaches involved with youth sports, encourages concussion prevention measures, such as rule and technique changes to improve player safety, and advances the recognition of and response to concussion when it does occur.

Research indicates that interventions aimed at limiting the force of physical contact in youth sports can dramatically lower the incidence of injury among youth sports participants.[29] For example, the CDC's HUYS program was shown to reduce the rate of concussions sustained during football practice sessions and games by 34% and by 29%, respectively.[15] This analysis assumes more modest reductions in concussion incidence from SLHS outreach work involving thousands of youths participating in a variety of sports throughout Idaho.

Concussion Care Coordination

Coordinated concussion care provided by St. Luke's Concussion Clinic improves health outcomes in several ways. Since its inception in 2012, the St. Luke's Concussion Clinic has realized significant reductions in time to be seen by a healthcare provider following concussion with 93% of acute concussion patients seeing a healthcare provider within three business days (K. Pardue, personal communication, 2017). Research supports the effectiveness of timely concussion care. A recent study showed a marked decrease in concussion recovery time, as measured by length of RTP time, when youth athletes received care from a concussion specialist within one week of injury compared to a longer period of time.[30] The Concussion Clinic also channels patients to appropriate healthcare providers, avoiding unnecessary ED visits and referring to specialists when necessary. Reduced ED visits, along with reduced rates of CT scanning, are likely responsible for most cost savings from care coordination.[18]

Centralized, coordinated care can reduce number of ED visits, which can lead to fewer CT scans. Research shows that patients initially presenting to EDs are more likely to receive head CTs than patients initially presenting to a Sports Medicine clinic (48% and 19% respectively).[31] SLHS utilizes evidence-based clinical decision rules for CT scanning after concussion to benefit patients and conserve resources. A recent study showed significant cost savings from reduced rates of CT scans after institution of improved clinical decision rules. These cost savings are estimated at $160 per person and represent 38% of estimated direct medical cost savings from improved concussion care.[13,32] Reducing unnecessary radiation to patients is another major benefit of lowered CT scanning rates.

St. Luke's Concussion Clinic staff provides valuable patient education and family support as patients recover and transition back to school and activities. This education and support improves adherence to treatment plans, prevents premature return to sports and activities, and provides reassurance to patients and their families. Studies show decreased levels of somatic symptoms, cognitive deficits, and anxiety with provision of patient education. Further, patients are less likely to attribute comorbid conditions to concussion after patient education.[26,27]

Comparison to Other Cost Studies

A 2010 study of healthcare costs in children and adolescents during the first three years following concussion found healthcare costs in years two and three combined to be approximately $445 higher after inflation adjustment for subjects exposed to concussion compared to unexposed subjects, with 53% of year 1-3 medical costs occurring during year of injury.[33] This analysis yields similar results by calculating long-term costs of concussion sequelae of MDD, migraine, and epilepsy. The study team estimates post-concussion healthcare costs in years two and three combined at $502, with 65% of year 1-3 medical costs occurring during year of injury.

Limitations

The use of secondary, rather than primary, cost data is the most significant limitation of this study. Other limitations are related to uncertainty regarding the concussion incidence rate and scope of long-term sequelae. In recent years, the reported incidence rate for concussion has climbed significantly, possibly due in part to heightened public awareness of concussion leading more people to seek treatment. This may skew cost data as people with less severe injuries may now be seeking treatment compared to the recent past. This effect could lead to an overstatement of cost savings. RR ratios and odds ratios used in the analysis were adjusted for confounders, including history of mental illness, but it is possible that other confounders exist that were not accounted for in the studies. This analysis assumes that all concussion-related headache is migraine. This assumption could lead to an overestimation of costs if migraine is more severe than other forms of headache associated with concussion.

Several factors could lead to an understatement of concussion costs. It is likely that there are long-term sequelae of concussion besides MDD, migraine, and epilepsy that were not incorporated in the analysis. For example, it is likely that a small but significant link exists between concussion and PD.[34] Only MDD was included as a psychiatric consequence of concussion, though it is likely that anxiety and less severe forms of depression are associated with concussion as well.[6]

Conclusion

Concussion is a significant and costly health problem with long-term consequences that can last for many years for some patients. The St. Luke's Concussion Clinic improves the health of Idahoans by advancing concussion awareness and primary prevention, and reducing the detrimental effects of concussion with coordinated, timely, and appropriate concussion care.

In addition, the Applied Research Division of SLHS, working in partnership with St. Luke's Concussion Clinic and Boise State University, is engaged in several concussion-related research projects. These research projects include *Analyzing the Effects of Repetitive Impacts to the Head Utilizing Diffusion Tensor Imaging, Quality of Life in Concussion Patients,* and *Parents as Advocators and Navigators: Perspectives Concerning Youth Sport Athletes with Post-Concussion Syndrome*. These studies add to the body of scientific knowledge regarding the effects of concussion on the brain and inform best practices for treatment of concussion patients. Results will be used to improve patient education, support family members of concussion patients, and coordinate care to optimize outcomes for those with concussion. These research projects also provide avenues for community outreach, education, and sharing of results, which may aid in concussion prevention and positively impact the health of children in areas served by SLHS.

Health systems such as SLHS are in unique positions to advance population health and promote wellness. They often enjoy the trust of communities they serve, and possess resources necessary for effective community outreach. When prevention and outreach are combined with coordinated clinical care for the sick and injured, collective positive impact on recipient communities is significant. This analysis seeks to quantify the impact of primary prevention and coordinated clinical care for concussion in Ada County and the state of Idaho, and estimates cost savings to be substantial.

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