Oregon Senate Bill 420

OR SB420 | 2023 | Regular Session

Chief Sponsors:

Senators Patterson, Taylor, Manning Jr and Representative Neron

Regular Sponsors:

Senators Findley, Gelser Blouin, Knopp, and Representatives Helm, Hudson

Summary

Directs Department of Human Services to provide specified services to individuals with brain injuries and to convene Brain Injury Advisory Committee. Requires department to report to Legislative Assembly during odd-numbered year regular sessions on services provided and number of individuals served.

cbirt The Center on Brain Injury Research and Training | UNIVERSITY OF OREGON

Table of Contents

Statement of David Kracke in Support of SB 420

January 23, 2023

My name is David Kracke and I am Oregon's Brain Injury Advocate Coordinator charged with improving the lives of Oregon's brain injury survivors, a goal that we can all agree is important. One of the most significant acts that this body could take in furtherance of that goal is to pass SB 420.

Oregon is recognized as a national leader when it comes to brain injury policy. We led the nation in 2009 with Max's law, the nation's first enacted youth sport's concussion law, continued with Jenna's law in 2013, and then again in 2020 with HB 4140, which will provide immediate academic accommodations to our concussed students upon their return to school.

With that being said, however, Oregon is failing to provide Brain Injury Resource Navigation. We are one of only eleven states that does not have a Brain Injury Resource Navigation program despite the fact that Brain Injury Resource Navigation is an evidence-based best practice for our brain injury survivors, enhancing the survivor's quality of life while realizing significant cost savings to the state.

Research shows that brain injury is disproportionately prevalent among underserved populations including individuals experiencing homelessness, veterans, those with mental and behavioral health concerns, victims of intimate partner violence, and those involved in the justice system. SB420 increases supports for these vulnerable populations who often face significant barriers and issues to accessing needed care. For more details on prevalence rates in these populations please see pages 46-87 in the attached exhibit packet.

A robust Brain Injury Resource Navigation program will require effort to implement, and luckily we are up to the task. We have the advantage of learning from other state's examples, we have access to some of the nation's leading experts for consultation purposes, and we have further evidence of the incredible benefits that Brain Injury Resource Navigation brings.

While the concept of Brain Injury Resource Navigation is simple, provide access to person-centered supports and services for Oregon's brain injury survivors, it is important to address the details that create the foundation of a robust Brain Injury Resource Navigation program. To explain some of those details, I have created an exhibit packet that is being submitted with this statement.

Within that exhibit packet you will find the following:

- First-hand accounts from Brain Injury survivors expressing how their lives would have been improved if they had had access to Brain Injury Resource Navigation;
- Preliminary results from a 2021 - 2022 Center on Brain Injury Research and Training (CBIRT) Survey indicating significant gaps in access to person-centered supports and services in Oregon;
- An OHSU healthcare economic analysis identifying significant cost savings to the state associated with Brain Injury Resource Navigation; and
- Evidence-based studies demonstrating:
    - The benefits of Brain Injury Resource Navigation
    - The prevalence of brain injury in individuals experiencing homelessness, veterans, those with mental and behavioral health concerns, and victims of intimate partner violence
    - The significant reduction in recidivism rates among brain injured inmates who receive Brain Injury Resource Navigation post-release

In addition to the written materials presented here, you will also hear direct testimony from a few of Oregon's brain injury survivors as they recount their personal experiences in this area.

For these reasons and more, I urge you to please support SB 420. Thank you.

David Kracke

Oregon's Brain Injury Advocate Coordinator

dkracke@cbirt.org; Phone: 503-887-7297;

Center on Brain Injury Research and Training, University of Oregon.

Why we need Resource Navigation

After brain injury, most of the focus is on medical, physical, and emotional healing. Survivors' and families' needs and desires go well beyond medical care, but we often do not know our legal rights, what can be made available to us, or how to find providers who understand brain injury.

- Employment
- Education
- Medical Services
- Social Services
- Mental Health
- Housing
- SSI and SSDI
- Legal Representation
- Transportation
- Support Groups
- Volunteering
- Life Skills Development
- Assistive Technology
- Many Other Services

Resource Navigators bridge the gaps for people who need accommodations but are unsure whether they could qualify and may lack resources or knowledge of how to secure them on their own.

Who can benefit from Resource Navigation

My name is Cheryl. I now work full-time and advocate for people with disabilities through media arts and community service.

My recovery could have been smoother if I had had more information. My Master's in Speech-Language Pathology helped me in many ways, but I'd had over two decades of sports concussions and mild TBIs. After a serious bike wreck in 2010 when I was 35, my self-awareness was too impaired for me to know I should or even could get help. My doctor did not refer me to rehab until a speech therapist approached me and recommended I ask for a referral.

I tried to return to work, but supervisors offered support without an accommodation plan, which was inadequate. After taking medical leave, I resigned in shame. A **Resource Navigator** could have supported me to recognize my needs were outside the reasonable range.

"I know I can do this job if you just let me come in only 5 hours a week."

My physical therapist sent me to a support group for teenagers. I only learned about adult support groups through a flyer. I was later referred to a Certified Rehabilitation Counselor.

The counselor helped me apply for para-transit, which restored my ability to travel independently. Learning about transportation options sooner through a **Resource Navigator** would have freed my family from driving me to medical appointments during their workday.

Dani lost her friends and her ability to play the sports she loved after waking from a coma with substantial cognitive and physical impairments. She was suspended and expelled repeatedly from multiple high schools for her behavior after the brain injury.

She barely graduated after seven years and continues to struggle to find life direction. A **Resource Navigator** may have been able to steer her toward information and support in such varied areas as dealing with trauma, connecting to other peers, adaptive sports, and advocating for more behavior supports in school.

"I tried to kill myself a few times, a lotta times actually. I walked in roads late at night. I overdosed a few times. I cut myself and hit my head against the walls. I heard if I had any big impact to my head, I could instantly die."

Dani has held only one job as an adult and is housing insecure. A **Resource Navigator** has the knowledge to assist people with disabilities to find appropriate housing, social supports, positive outlets for expressing oneself, and creating a plan for education and employment goals.

Brandon went from straight As to failing after a severe TBI. Although given an accommodation plan, his supports were not adequate for his impairment level. He did not recognize his legal right to address this.

A **Resource Navigator** could have assisted him to discuss accommodations with his college or help him realize that taking one more year off could have benefited him in working toward his degree.

"At Multnomah Bible College, I feel like there probably could've been more interaction with me on a personal level. I got an F because they didn't teach it to me correctly."

Brandon was in a supported living facility for several years. He now lives independently in his own apartment but would have preferred to move out sooner.

A **Resource Navigator** might have helped him and his family manage his finances and search for housing with in-home supports to encourage independence sooner. He has become frustrated being a long-term volunteer at a bakery and is only now beginning to seek paid employment more than a decade after his injury.

Oregon Brain Injury Services and Supports Survey

Initial Findings

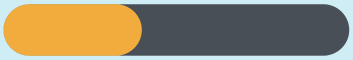
This data reflects the first 122 participants to complete the survey (51 stakeholders & 71 providers). We are continuing to collect data and will provide updated results when the study is complete.

Persons with Brain Injury

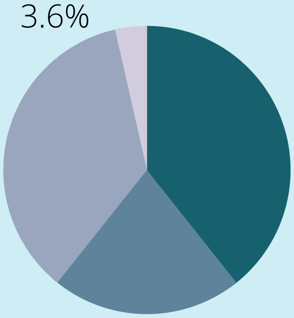
What has kept you from the service(s) you need?

I was not aware of the services

I don't understand the process to get services

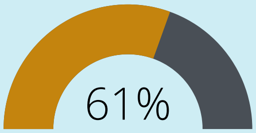


Have you received the Case Management service(s) you need?

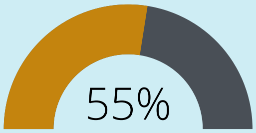


What could improve how you get the services and supports you need?

Having someone to turn to for support and to ask questions of, even years after my injury.



Having one person to help coordinate my services and supports.



This survey was conducted by the Center on Brain Injury Research and Training with funding from the Administration for Community Living's Traumatic Brain Injury State Partnership Program to gauge the state of services and supports for Oregonians with brain injury.

Is there anything else you would like to share about your experience getting the services you need or needed?

“I had to be my own case manager for a long time and it's nearly impossible when you have a brain injury.”

“It was really hard. I had to ask and ask and ask for help and services. Nothing was offered.”

“I spent 2 years at over 500 appointments and over 40 practitioners and today, I am in Illinois, Chicago area, receiving medical attention that could not or would not be available to me in Oregon. That is how bad it is in Oregon. I had to leave to get more cohesive TBI care. Oh, I'm still an Oregon resident. I'm living in a residential hotel while here for months. It is driving public services costs up, unemployment, homelessness, not to mention broken families and lives, on top of personal debt, and for some, death.”

Is there anything else you would like to share about how your services are coordinated?

“I do it all myself! I wish I had a case manager who managed it all. However I have several, and they do not communicate with each other.”

“What coordination? I didn't know this was an option.”

“I didn't know case managers were available.”

“I did not receive any case management services. No one ever suggested such although I asked. I didn't know how.”

“Resources, medical providers, prescription sites, knowledge, are all so detached and disparate that navigating it all is like assault and battery to a Person with TBI. Clearly I'm disgusted by the experience and humiliation, so I'm sharing in hopes that you can make a difference.”

Service Providers

40%

Indicate an unmet need for case management for individuals with brain injury in their community

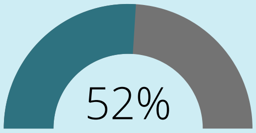
55%

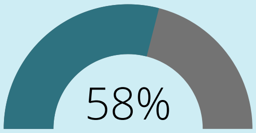
Perceive challenges in care coordination and navigating siloed systems of care as a barrier to providing services to individuals with brain injury

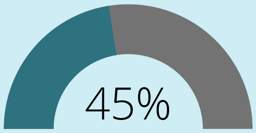
56%

Indicate client access to a single, long term case manager to help coordinate their services and supports could improve care coordination

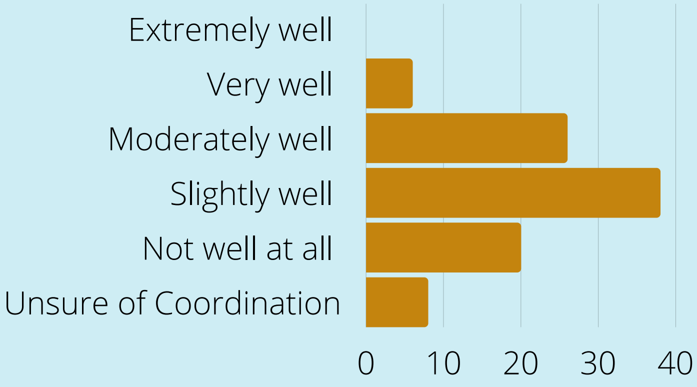
In your opinion, what are the biggest challenges for clients with brain injuries in obtaining the services they need?


Client unaware of services


Client difficulty in understanding the process to get services


Providers unaware of additional brain injury services

How well coordinated are brain injury services and supports in your region?



Is there anything else you would like to share about barriers to services for clients with brain injury?

> For adults who are typically independent and who are living alone, TBI and disruption of executive functioning cause significant issues accessing and coordinating care. A nurse navigator or someone like that to help organize and help patients attend appointments and follow through with recommendations would help them tremendously. Children often have parent advocates to help them.
> Many adults do not.

> Too many systems interacting with these patients, the patient's need for services or level of impact is not as obvious, creating many frustrations for patients.

Is there anything else you would like to share about how services are coordinated for clients with brain injury?

> We have seen people shuffled from one place to another without the ability to properly address the brain injury and its implications. Often the client themselves are frustrated with or don't understand the process and so compliance with recommended treatment is low.

Cost Savings to the State of Oregon due to Resource Facilitation for Individuals with Traumatic Brain Injury

Stephan Lindner, Ph.D.
June 10, 2020

Introduction

This report examines potential cost savings to the state of Oregon if it implemented a state-wide brain injury resource facilitation program to support people with brain injury, including traumatic brain injury (TBI), and their families. In this context, resource facilitation is a system where trained navigators provide critical information concerning available services and supports to brain injury survivors and their family members.

Most calculations are based on program data for Iowa assembled by Geoffrey Lauer, Chief Executive Officer of the Brain Injury Alliance of Iowa. Iowa has an established resource facilitation program in place, which currently serves about 1,000 people per year. Oregon's population is 35 percent higher (Iowa: 3.1 million; Oregon: 4.2 million) implying that a similar program could enroll about 1,350 people with TBI annually.

I focus on four sources of cost savings that resource facilitation can create: savings due to (i) a shift from institutionalized care to home- and community-based services, (ii) a reduction in psychiatric inpatient stays, (iii) a reduction in the number of people enrolled in Medicaid, and (iv) a reduction in the number of people in jail. While high-quality, peer-review evidence on most of these channels is currently lacking, calculations using Iowa's program data and plausible assumptions suggest significant potential for resource facilitation to reduce state expenditures. Specifically, estimated annual savings are:

- Shift towards home- and community-based services: $267,799 annually.
- Avoidance of psychiatric inpatient stays: $70,000 annually.
- Reduction in the number of Medicaid enrollees: $18,935 annually.
- Reduction in the number of people in jail: $20,250 annually.

Longer-term cost savings could be of a magnitude higher. For instance, the 10-year discounted cost savings for a scenario where enrollment gradually increases to

1,350 program participants within five years of program initiation are estimated to be $3,600,916 under the assumption that annual cost savings per person with TBI do not extend over several years. Assuming further that costs savings for people with TBI who switch to home- and community-based services because of resource facilitation extend to an average of 10 years, would yield to even higher cost savings: the 10-year discounted costs savings for the same gradual enrollment scenario are estimated to be $13,987,407 in this case.

Source #1: Shift from institutionalized care to home- and community-based services (HCBS)

Context: People who require medical services provided in an institutional setting may alternatively receive home- and community-based services (HCBS). Providing home-and community-based services instead of institutional care has the potential of delivering substantial cost savings to the state: HCBS waivers are required to be cost neutral (i.e., not to exceed the state estimated expenditures for comparable levels of institutional care), and states that had non-institutional care programs experienced lower spending growth than states that did not have such programs in place (Kaye et al., 2009; Kitchener et al., 2006). However, not all people who could receive HCBS may know about this option. Resource facilitation has the potential to increase the number of people with TBI on HCBS by providing information and guidance.

Potential cost savings per person: There exists little evidence regarding potential cost savings due to HCBS. The most comprehensive study calculated average waiver and institutional costs by state and reported a potential cost savings of $164,193 per person and year for Oregon (Harrington et al., 2011). I estimate that the state of Oregon pays about 23.3 percent of average Medicaid costs (see Appendix for details), which implies that the state could save $38,257 annually per person switching from institutional care to HCBS.

Potential number of people affected: To my best knowledge, there are no studies examining the effect of resource facilitation on the number of people receiving HCBS. Iowa program data suggests that resource facilitation could avoid 7 institutional care cases per 1,000 people served.

Potential overall cost savings: Resources facilitation would reduce state expenditures by $267,799 annually under these assumptions.

Source #2: Psychiatric inpatient stays avoidance

Context: An analysis provided by the Oregon State Hospital showed that 188 out of 3,206 patients served at the hospital between January 1, 2016 and May 8, 2019, or 5.9 percent, had TBI as a primary diagnosis. This includes patients with a new TBI diagnosis and patients who were previously diagnosed with TBI. Resource facilitation could lower the number of people with TBI admitted to the state hospital by facilitating better care or better care coordination.

Potential cost savings per case: The average hospital expenses per inpatient day was $4,062 in Oregon in 2017.[1] A recent article in the Oregonian reported inpatient costs in the amount of $1,324 per day and patient, but did not mention whether these are costs to the state or overall costs.[2] In what follows, I conservatively assume that an inpatient stay costs the state on average $1,000 per day and patient.

Potential number of avoided cases: To my best knowledge, there are no studies examining the effect of resource facilitation on psychiatric inpatient stays. Iowa program data suggests that resource facilitation could avoid 7 stays per 1,000 people served, with each stay being on average 10 days long.

Potential overall cost savings: Resource facilitation could reduce state expenditures by a total of $70,000 annually under these assumptions.

Source #3: Reduction in the number of people enrolled in Medicaid

Context: Oregon currently covers about 850,000 people through its Medicaid program.[3] The state expanded its program with the Patient Protection and Affordable Care Act in 2014. Since then, all adults with income below 138 percent of the poverty level are eligible for Medicaid. Currently, 94 percent of Oregonians are insured.[4] People with TBI who were previously not enrolled in Medicaid might enroll in the program because they are unable to find work after their injury. Resource facilitation could support re-employment and therefore could reduce the number of people with TBI enrolled in Medicaid.

---

[1] https://www.kff.org/health-costs/state-indicator/expenses-per-inpatient-day-by-ownership/

[2] https://www.oregonlive.com/pacific-northwest-news/2019/05/oregon-mental-hospital-is-worlds-most-expensive-homeless-shelter-state-health-director-says.html

[3] https://www.medicaid.gov/medicaid/program-information/medicaid-and-chip-enrollment-data/report-highlights/index.html

[4] Author's calculations using the American Community Survey.

Potential cost savings per case: Average Medicaid expenditures for people with disabilities were $16,252 in Oregon in 2014.[5] Using this number as a proxy for Medicaid costs for people with TBI, and assuming an average state matching rate of 23.3 percent (own calculations; see Appendix for details), implies that the state pays on average $3,787 per Medicaid beneficiary with TBI.

Potential number of people affected: There exists clear evidence from peer-reviewed journal articles that resource facilitation has a positive effect on employment. In two randomized control trials taking place in Indiana, Trexler and colleagues have shown that resource facilitation increases employment rates of people with TBI by about 25 percent – a substantial program effect (Trexler et al., 2010, 2016).

Assuming that people with TBI are equally likely to be on Medicaid compared to the general population implies that 200 out of 1,000 cases of people with TBI are enrolled in Medicaid. Of these, 50 would be able to find a job due to resource facilitation if the employment effect of resource facilitation was 25 percent. Assuming further that one in five of them leave the program due to having found employment implies that 10 out of 1,000 people with TBI served by resource facilitation would leave Medicaid rolls due to employment.

Resource facilitation could also increase enrollment in Medicaid by encouraging some people with TBI to enroll in the program. In 2017, about 6 percent of people living in Oregon reported not having insurance.[6] Of these, 35 percent had an income below 138 percent of the poverty level. Applying the same numbers to people with TBI implies that about 20 out of 1,000 cases do not have insurance and could qualify for Medicaid based on their income. Assuming further that the program caused 25 percent of them to gain insurance implies that 5 people per 1,000 cases gain Medicaid insurance through resource facilitation.

Taken together, the net decrease in Medicaid enrollment due to resource facilitation is estimated to be 5 per year.

Potential cost savings: Resource facilitation would reduce state expenditures by $18,935 annually under these assumptions.

Source #4: Reduction in the number of people in jail

Context: Incarcerated people have a much higher prevalence of traumatic brain injuries (Farrer and Hedges, 2011; Slaughter et al., 2003; CDC, 2007). Resource facilitation could lower jail rates among people with TBI by providing resources and support.

---

[5] Conversation with Geoffrey Lauer and https://www.kff.org/medicaid/state-indicator/medicaid-spending-per-enrollee/

[6] Author's calculations using the American Community Survey.

Potential costs savings per avoided jail stay: I assume that jail stays cost the state $45 per person and day. This number is conservatively based on a study that reports costs of $85 per jail day for Kansas.[7]

Potential number of jail days avoided: Iowa program data suggests that resource facilitation avoids 18 jail stays, with an average length of 25 days.

Potential cost savings: Resource facilitation could reduce state expenditures by $20,250 annually under these assumptions.

Long-term cost savings

In this section, I report estimated cumulative 10-year savings per 1,000 people served by resource facilitation, as well as estimated 10-year cumulative savings under a scenario where program participation first increases before reaching a stable level. Table 1 shows total cumulative cost savings across all cost savings domains by scenario and year, and Table 2 shows cumulative discounted cost savings for the scenario with gradual enrollment and each of the cost savings domains. Discounted cumulative cost savings express future savings as present value using a discount rate, assumed to be 4 percent annually.

Table 1: Total cumulative cost savings by year

	Scenario: per 1,000 enrollees		Scenario: gradual enrollment increase		
Year	Cumulative undiscounted	Cumulative discounted	Enrollment	Cumulative undiscounted	Cumulative discounted
1	376,984	376,984	500	188,492	188,492
2	753,968	739,469	800	490,079	478,480
3	1,130,952	1,088,012	1,000	867,063	827,023
4	1,507,936	1,423,149	1,200	1,319,444	1,229,187
5	1,884,920	1,745,396	1,350	1,828,372	1,664,222
6	2,261,904	2,055,250	1,350	2,337,301	2,082,524
7	2,638,888	2,353,186	1,350	2,846,229	2,484,737
8	3,015,872	2,639,663	1,350	3,355,158	2,871,481
9	3,392,856	2,915,121	1,350	3,864,086	3,243,350
10	3,769,840	3,179,985	1,350	4,373,014	3,600,916

Total annual cost savings across all four domains described above is estimated to be $376,984. Cumulative 10-year cost savings if 1,000 people were served each year thus

---

[7] https://storage.googleapis.com/vera-web-assets/downloads/Publications/the-price-of-jails-measuring-the-taxpayer-cost-of-local-incarceration/legacy_downloads/price-of-jails-summary.pdf

Table 2: Cumulative cost savings by domain and year

Year	HCBS	Inpatient stays	Medicaid disenrollment	Jail avoidance
1	133,900	35,000	9,468	10,125
2	339,899	88,846	24,033	25,702
3	587,494	153,565	41,539	44,424
4	873,181	228,241	61,739	66,027
5	1,182,217	309,020	83,590	89,395
6	1,479,367	386,692	104,600	111,864
7	1,765,089	461,377	124,802	133,470
8	2,039,821	533,189	144,228	154,244
9	2,303,986	602,239	162,906	174,219
10	2,557,991	668,634	180,865	193,426

amount to \$3,769,840. The corresponding discounted cumulative 10-year cost savings are \$3,179,985. In a scenario where enrollment in resource facilitation starts at a lower level, increases during the first program years, and then reaches a plateau comparable of that found in Iowa (taking differences in population into account), cumulative 10-year cost savings are estimated to be \$4,373,014 (undiscounted) and \$3,600,916 (discounted), respectively. Cost savings due to a shift from institutionalized care to HCBS account for more than two-thirds of the total cost savings, followed by cost savings due to a reduction in inpatient stays, jail avoidance and, finally, Medicaid disenrollment.

The calculations thus far assume that resource facilitation only reduces costs during the year it is provided to people with TBI. This assumption seems not very realistic for some of the domains. Specifically, patients who switch to HCBS instead of using institutionalized care due to resource facilitation likely remain in HCBS for several years. As a result, the initial resource facilitation leads to further cost savings for the same patient during subsequent years.

As an alternative scenario, I assume that cost savings from HCBS extend to an average of 10 years. Under this assumption, cost savings from resource facilitation increase dramatically over time (Tables 3 and 4). The 10-year cumulative cost savings are estimated to be \$13,907,945 (1,000 people served each year, undiscounted), \$11,182,550 (1,000 people served each year, discounted), \$17,609,936 (gradually roll-out, undiscounted), and \$13,987,407 (gradually roll-out, discounted). The Appendix describes these calculations in further detail.

Table 3: Total cumulative cost savings by year, longer HCBS stays

	Scenario: per 1,000 enrollees		Scenario: gradual enrollment increase		
Year	Cumulative undiscounted	Cumulative discounted	Enrollment	Cumulative undiscounted	Cumulative discounted
1	376,984	376,984	500	188,492	188,492
2	1,021,767	996,968	800	704,318	684,479
3	1,934,349	1,840,701	1,000	1,616,900	1,528,212
4	3,076,473	2,856,045	1,200	2,987,449	2,746,625
5	4,448,139	4,028,551	1,350	4,839,198	4,329,508
6	6,011,090	5,313,183	1,350	6,949,182	6,063,761
7	7,765,326	6,699,581	1,350	9,317,401	7,935,399
8	9,672,590	8,148,945	1,350	11,892,207	9,892,040
9	11,732,882	9,654,380	1,350	14,673,601	11,924,377
10	13,907,945	11,182,550	1,350	17,609,936	13,987,407

Table 4: Cumulative cost savings by domain and year, longer HCBS stays

Year	HCBS	Inpatient stays	Medicaid disenrollment	Jail avoidance
1	133,900	35,000	9,468	10,125
2	545,898	88,846	24,033	25,702
3	1,288,684	153,565	41,539	44,424
4	2,390,618	228,241	61,739	66,027
5	3,847,503	309,020	83,590	89,395
6	5,460,604	386,692	104,600	111,864
7	7,215,750	461,377	124,802	133,470
8	9,060,379	533,189	144,228	154,244
9	10,985,013	602,239	162,906	174,219
10	12,944,482	668,634	180,865	193,426

Conclusions

The calculations presented here suggest potentially substantial cost savings of a brain injury resource facilitation program in Oregon. Most of these cost savings would come from redirecting people with TBI away from high-cost services to lower-cost services.

There are a number of reasons why actual cost savings might differ from the ones presented here. Brain injury resource facilitation may yield other possible cost savings or revenue increases to the state that are not included in this report, such as an increase in the income tax or a reduction in prison stays. Conversely, brain injury resource facilitation could increase program utilization, which in turn could imply higher costs to the state. Finally, most calculations presented in this report are based on program data from Iowa, and these might not translate exactly to Oregon.

The cost savings calculations presented here do not include all benefits of a brain injury resource facilitation program. For instance, better return to work prospects may lead to better social relationships. Similarly, brain injury resource facilitation could improve care for chronic conditions or lower homelessness rates, which could increase quality of life among people with TBI. Such benefits of brain injury resource facilitation often go hand in hand with cost reductions, if, for instance, better care coordination implies fewer visits to hospitals, but in some instances, they may imply higher costs through higher service utilization.

Stephan Linder, PhD, is a Research Assistant Professor at the Center for Health System Effectiveness (CHSE), Oregon Health Sciences University, Portland, OR. Dr. Lindner is a health and labor economist who evaluates the effectiveness of health policy programs and policies. Oregon's Administration for Community Living TBI Partnership grant - 90TBSG0039 - supported this work.

References

CDC (2007). Traumatic brain injury in prisons and jails: An unrecognized problem. Centers for Disease Control and Prevention.

Farrer, T. J. and D. W. Hedges (2011). Prevalence of traumatic brain injury in incarcerated groups compared to the general population: a meta-analysis. *Progress in Neuro-Psychopharmacology and Biological Psychiatry 35*(2), 390–394.

Harrington, C., T. Ng, and M. Kitchener (2011). Do Medicaid home and community based service waivers save money? *Home Health Care Services Quarterly 30*(4), 198–213.

Kaye, H. S., M. P. LaPlante, and C. Harrington (2009). Do noninstitutional long-term care services reduce Medicaid spending? *Health Affairs 28*(1), 262–272.

Kitchener, M., T. Ng, N. Miller, and C. Harrington (2006). Institutional and community-based long-term care: a comparative estimate of public costs. *Journal of Health & Social Policy 22*(2), 31–50.

Slaughter, B., J. R. Fann, and D. Ehde (2003). Traumatic brain injury in a county jail population: Prevalence, neuropsychological functioning and psychiatric disorders. *Brain Injury 17*(9), 731–741.

Trexler, L. E., D. R. Parrott, and J. F. Malec (2016). Replication of a prospective randomized controlled trial of resource facilitation to improve return to work and school after brain injury. *Archives of Physical Medicine and Rehabilitation 97*(2), 204–210.

Trexler, L. E., L. C. Trexler, J. F. Malec, D. Klyce, and D. Parrott (2010). Prospective randomized controlled trial of resource facilitation on community participation and vocational outcome following brain injury. *The Journal of Head Trauma Rehabilitation 25*(6), 440–446.

Appendix

There are three federal matching rates relevant for Oregon's Medicaid program:[8]

- The traditional matching rate: The rate is 61.23 percent in Oregon for the 2020 fiscal year.[9]
- The newly-eligible matching rate: The federal matching rate is 90 percent starting 2020.
- The Children's Health Insurance Program (CHIP) matching rate: The rate is 84.36 percent in Oregon for the fiscal year.[10]

The number of newly eligible Medicaid recipients due to the ACA was estimated to be about 550,000 when 964,000 people were enrolled in the program in 2018.[11] KFF reported that about 850,000 people were enrolled in Medicaid in February 2019, and about 125,000 children enrolled in CHIP, for a total of about 975,000.[12] Based on these numbers, it is reasonable to assume that about half of the adult Medicaid population in Oregon is enrolled through the ACA. This implies the following fractions: 43.6 percent traditional Medicaid enrollees; 43.6 percent newly eligible Medicaid enrollees; and 12.8 percent CHIP enrollees. Applying the matching rates to these fractions implies a weighted average matching rate of 0.767 ($0.436 \cdot 0.6123 + 0.436 \cdot 0.9 + 0.128 \cdot 0.8436 = 0.767$), which in turn implies that the state of Oregon pays 23.3 percent of Medicaid and CHIP expenditures.

I assume that for a cohort of 7 people with TBI who switch to HCBS because of resource facilitation:

- One person stays on the program for three years;
- One person stays on the program for six years;
- One person stays on the program for eight years;
- One person stays on the program for 10 years;
- One person stays on the program for 12 years;

---

[8] https://www.kff.org/medicaid/issue-brief/understanding-how-states-access-the-aca-enhanced-medicaid-match-rates/

[9] https://www.kff.org/medicaid/issue-brief/understanding-how-states-access-the-aca-enhanced-medicaid-match-rates/

[10] https://www.kff.org/other/state-indicator/enhanced-federal-matching-rate-chip/

[11] https://www.healthinsurance.org/oregon-medicaid/

[12] https://www.medicaid.gov/medicaid/program-information/medicaid-and-chip-enrollment-data/report-highlights/index.html

- One person stays on the program for 14 years; and
- One person stays on the program for 17 years.

The average HCBS program duration is thus 10 years. I further assume that these people would not have switched to HCBS in the absence of resource facilitation during the 10-year period.

Based on these assumptions, the number of people with TBI who switched to HCBS due to resource facilitation is:

- 7 during the first program year;
- 14 during the second program year;
- 21 during the third program year;
- 27 during the fourth program year;
- 33 during the fifth program year;
- 38 during the sixth program year;
- 43 during the seventh program year;
- 47 during the eighth program year;
- 51 during the ninth program year;
- 54 during the tenth program year.

The results shown in Tables 3 and 4 then follow from using these numbers for HCBS cost savings.

Journal of Vocational Rehabilitation 49 (2018) 195–203
DOI:10.3233/JVR-180965
IOS Press

Models of brain injury vocational rehabilitation: The evidence for resource facilitation from efficacy to effectiveness

Lance E. Trexler* and Devan R. Parrott
Rehabilitation Hospital of Indiana, Indiana University School of Medicine, Indianapolis, IN, USA

Revised/Accepted October 2017

Abstract.

BACKGROUND: Resource Facilitation (RF) is an intervention developed to improve return to work (RTW) following brain injury. RF is an individualized treatment specializing in connecting patients and caregivers with community-based resources and services to mitigate barriers to return to work.

OBJECTIVES: Examine the effectiveness of the RHI RF program for a clinical prospective cohort of participants referred to this program from the State Vocational Rehabilitation agency.

METHODS: Participants were 243 participants with data drawn from the two sources: 33 from previous randomized controlled trial (RCT) control groups who did not receive RF and 210 from clinical patients discharged from the RHI RF program.

RESULTS: At discharge from RF, a greater proportion of the treatment group obtained employment than the control group [$X^2_{(1)} = 5.39, p = 0.018$]. When controlling for baseline level of disability, treatment group significantly predicted employment outcome (Wald = 4.52, $p = 0.033$) and participants in the treatment group were 2.3 times more likely to return to work than controls.

CONCLUSIONS: Previous RCTs have studied the RHI RF model and demonstrated significant efficacy. The findings from the present study are consistent with the employment rates found in the previous RCT's following RF, and also provide initial support for the clinical effectiveness of RF.

Keywords: Brain injuries, return to work, employment, rehabilitation, vocational

1. Return to work (RTW) after acquired brain injury (ABI)

Return to work after brain injury has always been regarded as a critical outcome metric in research, yet established continuums of rehabilitation services typically do not extend through vocational placement and follow-up. When vocational services do exist, they are often a) not brain injury specialized or b) integrated into an existing continuum of services, which typically results in people not receiving vocational rehabilitation services, or if they do, it is many years post-injury. In addition to the brain injury specific barriers to RTW, these system barriers compromise vocational outcome.

A variety of studies have demonstrated that approximately 30–40% of people with ABI ultimately return to work. A systematic review (Van Velzen, Van Bennekom, Edekaar, Sluiter, &

---

*Address for correspondence: Lance E. Trexler, PhD, FACRM, Rehabilitation Hospital of Indiana, Indiana University School of Medicine, 9531 Valparaiso Court, Indianapolis, IN 46268, USA. Tel.: +1 317 329 2411; Fax: +1 317 872 0914; E-mail: lance.trexler@rhin.com.

Frings-Dresen, 2009) found that 40.8% of those with traumatic brain injury (TBI) and 39.3% with non-TBI returned to work. Inclusion criteria in this review included a) the subjects were working prior to their injury, b) were aged 18–65 years, and c) return to work was an outcome measure. Their review was based on a sample of 49 studies that met all of the inclusion criteria. It should be noted however that this study did not separate outcomes based on severity of injury.

A more recent study was completed using population estimates from the Traumatic Brain Injury Model Systems National Database (TBIMS-NDB) (Cuthbert et al., 2015). In this study, the investigators culled 3121 subjects from the database which were weighted to obtain population estimates to match the US TBI rehabilitation population based on both the Uniform Data System for Medical Rehabilitation (UDS, 2012) and the American Medical Rehabilitation Providers Association, eRehab (American Medical Rehabilitation Providers Association, 2012). Their sample was based on inclusion criteria that included less than 60 at the age of injury, not retired at injury, and alive two years post-injury. These investigators found that 39.6% were employed, which included paid legal or illegal work, with or without accommodations. Of these 39.6% that were able to RTW, 65% of them were employed full time.

A number of studies have found that severity of brain injury has a significant impact on return to work. For example, in 2002, Groswasser et al. found that 84% of subjects with mild TBI were able to RTW, and in another study of mild TBI, 78% were able to RTW (Hanlon et al., 1999). Dikmen and colleagues (Dikmen, Temkin, Machamer, Holubkov, Fraser, & Winn 1994) found that 37 percent of subjects with severe traumatic brain injury (TBI) had returned to work, 64 percent with moderate TBI, and 83 percent of mild TBI returned to work at two years post-injury.

Even these findings may however over-estimate rates of RTW for moderate and severe brain injury. Certainly not all people who need inpatient rehabilitation receive these services, and consequently, are not included into the TBIMS database. Individuals who are seen in their State Vocational Rehabilitation agency are typically many years post-injury, did not have access to specialized brain injury rehabilitation services, have developed multiple co-morbidities, have lost vocational skills and networks, in addition to presenting with persisting cognitive and neurobehavioral disabilities (often among others), making return to work a certain challenge. For example, Schopp, Johnstone, Unger, & Goldman (2003) found that only 18 percent of State Vocational Rehabilitation clients with TBI were successfully placed.

2. Barriers to RTW after acquired brain injury

Vocational rehabilitation of people with brain injury represents a significant challenge from all perspectives. Barriers to RTW span across individual and family variables, as well as social, environmental, and system/organizational domains. It is for these reasons that an effective approach to RTW following brain injury will not be a "medical" or a "vocational" model, but rather one that is capable of responding to the unique and individualized constellation of barriers, and the interactions that each case presents.

Critical individual barriers include neurobehavioral impairments (e.g., disinhibition, impulsivity, decreased initiation) or cognitive impairments (e.g., impaired goal setting or task monitoring, memory, attention) that are ubiquitous following ABI and can significantly affect job performance and adjustment in the workplace (Dikmen et al., 1994). Medical consequences of brain injury (e.g., posttraumatic seizures) or co-morbidities (e.g., depression or substance abuse) also represent barriers to RTW or work stability. Level of behavioral adjustment post-injury affect family adjustment (Kreutzer, Marwitz, & Kepler, 1992), which in turn influence recovery and adaptation. Further, changes in social roles typically result in increased emotional and economic burden for family members, making it even more difficult to sustain family advocacy and emotional engagement, as well as support for the family member with the brain injury (Kolakowsky-Hayner & Kishore, 1999; Kreutzer, Gervasio, & Camplair, 1994).

Social barriers include lack of reimbursement for services and the absence of brain injury expertise among the host of providers involved in the vocational rehabilitation of people with brain injury. Multiple providers (e.g., employment services and cognitive rehabilitation) do not typically collaborate, compromising the potential effectiveness of each of their interventions. Awareness of State agency resources is typically lacking, and access to these resources can be cumbersome and overwhelming. Further, States do not typically have an organized State plan for brain injury, resulting in service silos within and between State agencies with resulting service gaps.

Complicating the vocational rehabilitation process even more is the fact that, at least in moderate to severe TBI, most people will have chronic disability that is variable in type and severity over time (Corrigan & Hammond, 2013). In fact, the severity of TBI disability has been found to vary more often that it remains static in long-term follow-up studies. Further, the individual and social-environmental variables dynamically interact with each other, where, for example, a loss of a significant relationship can result in depression that, in turn, results in further impairment of memory, which then results in impaired vocational performance. On the other hand, successful cognitive rehabilitation may result in new compensatory strategies, that when integrated into the work setting, with improvement in self-efficacy, and then a better response to psychotherapy for depression. Again, brain injury vocational rehabilitation is neither medical nor vocational; it is of necessity an individualized process of eliminating or mitigating brain injury-specific and other barriers with a holistic scope.

3. Models of vocational rehabilitation for acquired brain injury

A systematic review of the literature on different types of vocational rehabilitation for people with ABI (Fadyl & McPherson, 2009) demonstrated that there have been essentially three different approaches that included a supported employment (SE) model, a "Program-based vocational rehabilitation model" often referred to as a comprehensive day treatment program (CDT) model, and a "vocational case coordination (VCC)" model. The development of SE for people with brain injury was a significant contribution to improving vocational outcome (Wehman et al., 1989; Wehman, Bricout, & Targett, 2000; Wehman et al., 2003). Wehman and colleagues modified the individual placement model for people with brain injury and there was a clear emphasis on individualized training at the work site through a job coach rather than through pre-placement training and intervention. In contrast, the CDT program provided individual and group treatment for cognitive, neurobehavioral, and psychological difficulties driven by a neuropsychological approach (Ben-Yishay, Silver, Piasetsky, & Rattock, 1987; Prigatano et al., 1994). These programs were typically provided services four or five days a week for approximately six months and included family education and training, as well as vocational trials, placement and follow-up. The first two studies on "vocational case coordination," the third approach, were completed by Malec and colleagues (Malec, Buffington, Moessner, & Degiorgio, 2000; Malec & Moessner, 2006). This approach features an individualized approach to promoting access to vocationally-related needs and ensuring integration of services to impact on vocational skills and workplace adaptation. The overall structure of these different models from Fadyl and McPherson (2009) are provided in Fig. 1.

These investigators also rated the quality of the research for each of these models to determine the relative strength of experimental support for their effectiveness. Their findings in this respect are summarized in Table 1.

The research by Malec and colleagues (2000, 2005) on VCC and the systematic review by Fadyl and McPherson (2009) provided the scientific background for the development of the RF model developed at the Rehabilitation Hospital of Indiana (RHI).

3.1. The RHI resource facilitation model

The clinical research team at RHI incorporated the findings from a best practices guide from 16 RF programs in the United States completed by the then Brain Injury Association on "Resource Facilitation" into the VCC model (Brain Injury Association, 2001). RF was defined as "a partnership that helps individuals and communities choose, get and keep information, services and supports to make informed choices and meet their goals. The collaborative process involves participants (individuals with brain injury and their personal support systems) working in partnership with facilitators (individuals who provide assistance in navigating systems) to achieve agreed upon goals" (p. 2). This guide provided information on best practices while the research on VCC provided evidence to inform the RHI RF model. Like these 16 RF programs, RHI's development of RF program began with funding in 2009 from the Health Resources and Services Administration (HRSA).

The efficacy of the RHI RF model has been investigated through two randomized controlled trials (RCT). In the first RCT (L.E. Trexler, L.C. Trexler, Malec, Klyce, & Parrott, 2010), 22 subjects with ABI were recruited either while in the acute rehabilitation unit or shortly thereafter. It was found that the RF group had a successful return to work rate of 64 percent compared to 36 percent in the control

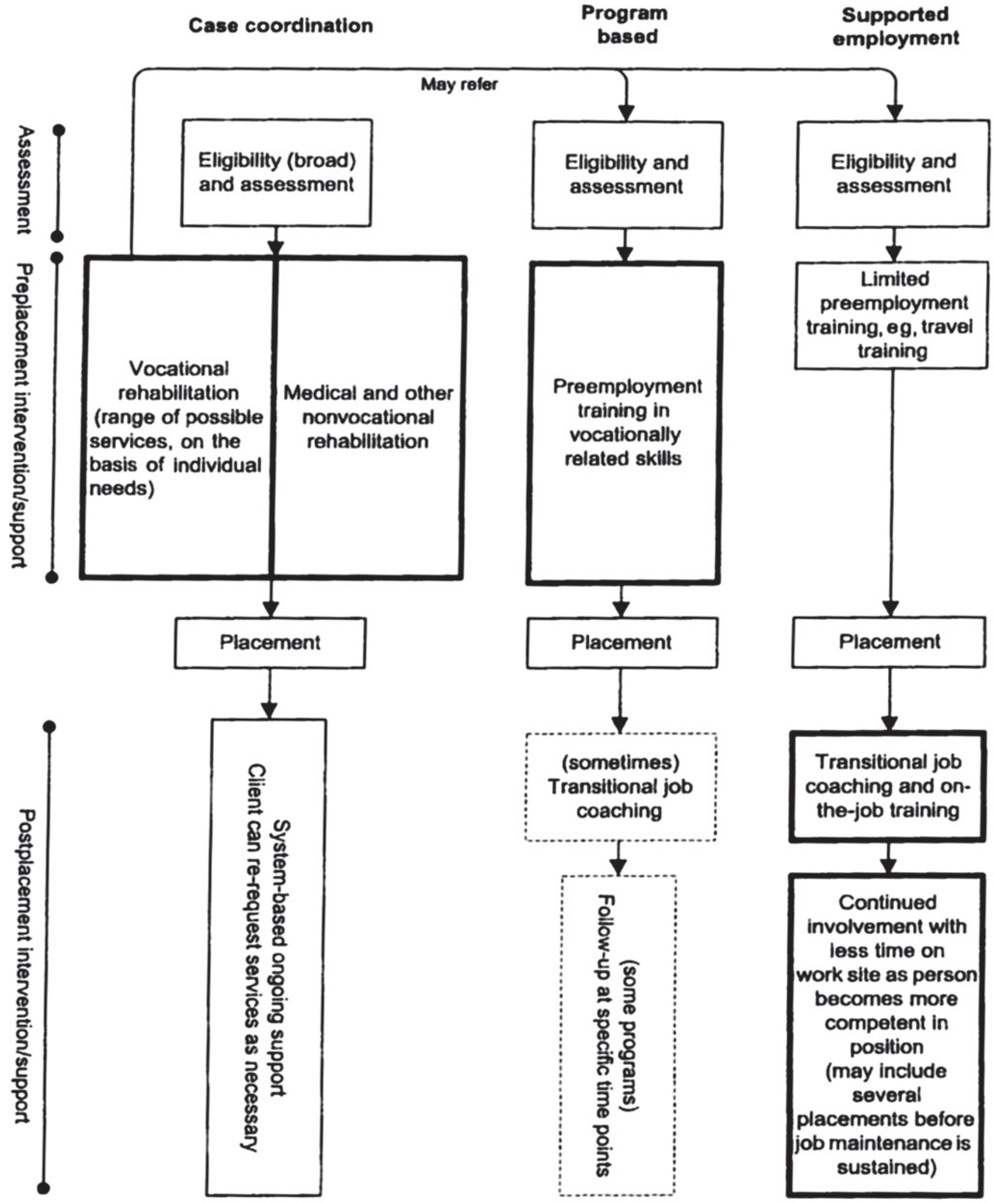


Fig. 1. Overview of the structure of three different types of vocational rehabilitation programs for brain injury (reproduced from Fadyl and McPherson, 2009 with permission).

group (Wald-Wolfkowitz $z = -3.27$, $P < 0.0001$). Further, the RF group was found to improve significantly more than the control on a measure of participation in activities at home and in the community relative to controls ($F = 9.11$, $P < 0.007$). A larger RCT of 44 subjects with ABI, again recruited while in an acute rehabilitation unit or shorter after being discharged, demonstrated that 69 percent of the RF group returned to employment compared 50 percent in the control group (Trexler, Parrott, & Malec, 2015). In addition, logistic regression analyses revealed that treatment group was a significant predictor of outcome (Wald = 4.91, $P = 0.027$), and RF participants with a goal of returning to work had 7 times higher odds of returning to productive activities relative to controls (95% confidence interval, (1.25, 39.15)). Based on these findings and the support for the efficacy of the RHI RF model, the Indiana Vocational Rehabilitation Services supported a prospective clinical cohort study to examine the effectiveness of

Table 1
Conclusions regarding the strength of the evidence for different types of vocational rehabilitation programs for brain injury

Comprehensive Day Treatment (CDT)	Supported Employment (SE)	Vocational Case Coordination (VCC)
Weak evidence for better vocational outcomes for those with TBI with CDT program	Weak evidence that SE "allows some individuals who have not been employed postinjury to be employed *specifically within the supported employment model*"	Moderate evidence that VCC "produces higher employment and productivity outcomes"
Weak evidence that that employment is maintained (approximately 50%)	Weak evidence that participants who receive SE are employed that lasts 90 days	Weak evidence that those who received VCC earlier after injury are employed earlier

RF. Further, as this trial was supported by the State Vocational Rehabilitation agency through referral of clients for RF, goals could be return to post-secondary education, although this was an infrequent goal.

4. Objectives

The overall objective of this study was to examine the effectiveness of the RHI RF program for a clinical prospective cohort of participants referred to this program from the Indiana Vocational Rehabilitation Services. Based on our previous research and previous research, we had two hypotheses that included 1) the participants in the RF prospective clinical cohort would demonstrate a significantly better rate of RTW or school, and 2) group assignment (RF versus controls) would predict outcome with baseline level of disability as a covariate.

5. Methods

5.1. Study design and population

The present study examined the vocational outcome for 243 participants (163 men and 80 women; mean age 38.59 ± 13.05 years) with data drawn from the two sources: 33 from the RCT control groups who did not receive RF and 210 from clinical patients discharged from the RHI RF program. Since the samples were from two different sources, the inclusion/exclusion criteria are different for each sample. For the control group, the inclusion criteria for the RCT was: a) TBI or diffuse encephalopathy including metabolic, infectious or toxic (but not due to alcohol abuse) encephalopathy, or intracranial hemorrhage, b) between 18–60 years old, c) English as a native language or non-native speaker with the assistance of a relative who is an English speaker or a translator, d) the individual with a brain injury had been employed at the time of injury, e) the individual had a return-to-work goal after the injury, and (f) participant or legal proxy consents to study participation. Exclusion criteria included: a) the presence of acute psychosis or the emergence of psychosis during the course of the study and b) history of treatment received for substance abuse within the preceding two years.

The obvious inclusion criteria for this clinical sample included a) a diagnosis of an acquired brain injury and b) a return to work or post-secondary school goal, or they would have not been appropriate clients of the State Vocational Rehabilitation agency. No explicit inclusion/exclusion criteria were applied to the clinical cohort sample. In general, participants who may have had an active psychosis were very likely excluded and some participants with alcohol or drug abuse to an extent to which would interfere with goal attainment were not admitted into RF. We also did not recommend RF for a few clients that had very severe physical, cognitive, and neurobehavioral impairment to an extent that the relative probability that they could become competitively and independently employed was very remote.

The duration of RF was on average nine months prior to the participant becoming competitively employed. Participants were then followed for 90 days to ensure that vocational supports were sustainable and that their employment adjustment was stable.

5.2. Measures

Return to either part- or full-time competitive work or post-secondary school was the main outcome measure, and data for the number of hours worked per week and type of work was available for 66% of the treatment sample that was successful for return to work or school. A successful outcome was recorded when the participant was able to sustain employment or return to school for the entirety of the interval between place and follow-up 90 days thereafter.

The Mayo-Portland Adaptability Inventory - 4 (MPAI-4) was designed to measure post-acute disability level in persons with brain injury (Malec, 2005). Change is MPAI-4 is also used to evaluate the effectiveness of rehabilitation programs. It consists of 28 total items and subscales measure cognitive and physical abilities, psychosocial adjustment and participation in activities at home and in the community. This measure was used as a covariate to determine if group assignment would predict employment outcome.

5.3. Statistical analyses

The present retrospective case-control study used control data from our previous RCT's as well as group data from a current clinical cohort who received RF services. Propensity scores were not utilized as the control group data were from subjects previously randomized to a control condition. However, baseline comparisons were used to ensure the groups were not statistically different from each other prior to treatment.

All analyses were completed using IBM SPSS version 24. Independent sample *t*-tests and Chi-square analyses were used to compare baseline variables between the two groups. A Chi-square analysis was used to compare the success rate in each group and logistic regression was used to predict employment status based on group assignment. Nagelkerke R^2 was used to estimate explained variance. There were no outliers, as assessed by examination of studentized residuals for values greater than three standard deviations. Effect size is reported as partial η^2. An effect size less than 0.05 was considered small; moderate, when between 0.05 and 0.25; moderately large, when between 0.25 and 0.50; and large when greater than 0.50. Significance levels were set at $p < 0.05$ and Bonferroni corrections were used to correct for multiple pairwise comparisons.

6. Results

Some very noteworthy demographic differences between the two groups were present at baseline: years post injury, age at injury, and injury type (see Table 2). As previously noted, the control group was derived from a previous RCT where subjects were recruited while in acute inpatient rehabilitation or shortly thereafter, and were a little more than two months post-injury. In marked contrast, the participants in the RF group in the present study were referred from Indiana Vocational Rehabilitation Services and were found to be, on average, over 9 years post-injury. Additionally, the age at injury for the RF group was found to be significantly younger (29.6 years) as compared to the control group which was on average 40 years old. This difference is likely attributable to significant differences between the two groups in terms of diagnosis, where there were more participants with stroke in the control group and more moderate to severe TBI subjects in the RF group.

6.1. Hypothesis 1: Success rate by group

Of the 210 participants in the treatment group, 69% ($n = 145$) were successful for return to competitive work. Six of these 145 successful outcomes were for participants that had a goal of return to school. Of the portion of the sample for which work hours and type of employment information was available, it was found that the average hours worked per week was 24.88 (sd = 10.38) and 36% of the successfully closed cases were full-time (30+ hours per week). The occupations to which they were placed are provided in Fig. 2. Almost half of the successful participants returned to either administrative support or laborer positions, but the other half were distributed across all other types of occupations. Of the 33 participants in the control group, 48% ($n = 16$) successfully returned to paid employment. This difference was significant, indicating a greater proportion of success in the treatment group than the control at the end of the treatment duration [$X^2_{(1)} = 5.39$, $p = 0.018$] (see Fig. 3).

6.2. Hypothesis 2: Treatment group predicts outcome with baseline level of disability as a covariate

The first model examined the relationship between baseline level of disability and employment. A logistic regression model was statistically significant, $\chi^2(1) = 9.92$, $p = 0.002$, but it should be noted that this model only explained 5.5% of the variance in productive activity and correctly classified 67.9% of the cases. Level of disability at baseline provided an exponential slope of 0.94 indicating that with every

Table 2
Patient characteristics and outcomes by group

Characteristic	Resource Facilitation ($n = 210$)	Controls ($n = 33$)	p
	Mean ± standard deviation	Mean ± standard deviation	
Age (y)	38.32 (13.28)	40.30 (11.54)	0.419
Years Post Injury	9.61 (10.30)	0.18 (0.10)	0.000
Age at Injury	29.61 (15.58)	40.30 (11.54)	0.000
Years of education	13.24 (2.21)	13.46 (2.24)	0.610
Baseline MPAI	42.36 (7.97)	43.70 (8.25)	0.373
	Frequency (%)	Frequency (%)	
Sex			
Male	142 (68%)	21 (64%)	
Female	68 (32%)	12 (36%)	0.692
Race			
White	191 (91%)	33 (100%)	
African American	16 (7.6%)		
Hispanic	3 (1.4%)		0.085
Diagnosis			
Mild TBI	2 (1%)	—	
Moderate to Severe TBI	152 (72%)	17 (52%)	
Stroke	33 (16%)	15 (46%)	
Other	23 (11%)	1 (3%)	0.001

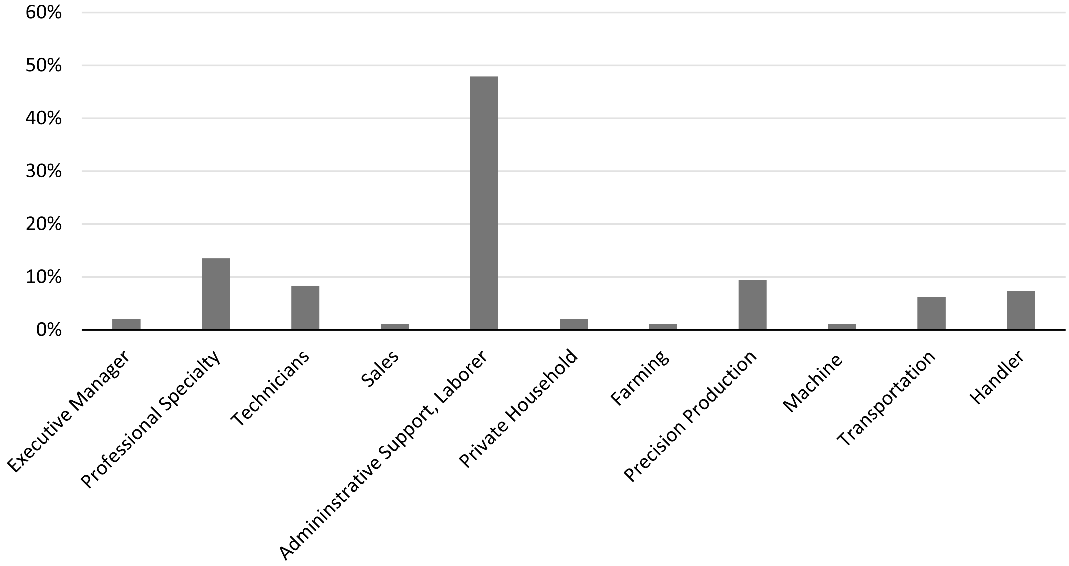


Fig. 2. Occupational categories for successfully closed cases.

one point increase in MPAI-4 T score (higher scores indicating a greater level of disability), the odds of successful employment declines by nearly one percent (Wald = 9.06, $p = .003$) (See Fig. 4).

Adding treatment group to the model and leaving level of disability as a covariate increased the models significance and improved the odds of successful employment for those in the treatment group. This model was also statistically significant, $\chi^2(2) = 14.41$, $p = 0.001$ and explained 8% of the variance in productive activity and correctly classified

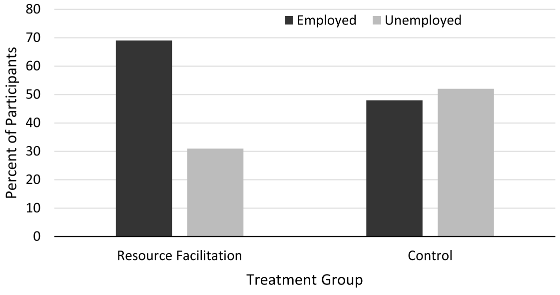


Fig. 3. Employment Rates for RF and Control Groups.

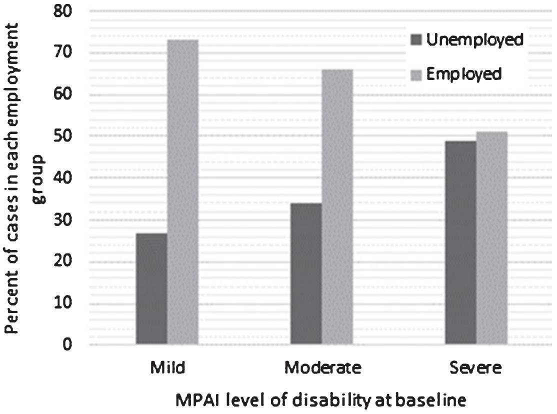


Fig. 4. Outcome by Initial Level of Disability.

Table 3

Summary of logistic regression analysis predicting employment

Variable	*B*	SE	Wald Statistic	*p*
Treatment Group	–0.824	0.388	4.52	0.033
Disability	–0.056	0.019	8.51	0.004

67.1% of the cases. When controlling for baseline level of disability, treatment group significantly predicted employment outcome (Wald = 4.52, $p = 0.033$) and participants in the treatment group were 2.3 times more likely to return to work than controls.

7. Conclusions

In conclusion, participants receiving RF had a higher employment rate than participants in past control groups. In fact, participants in the treatment group were over two times more likely to return to work than the control group when controlling for level of disability. As demonstrated by previous research, successful vocational outcome varied as a function of level of disability as measured by the MPAI-4, where 74% of participants with mild disability, 65% of participants with moderate disability, and 48% of participants with severe disability were successful with obtaining employment through RF. Further, the participants in RF were almost ten years post-injury as compared to the control group, which was slightly over two months post-injury. Additionally, the RTW rate of 69% for the RF cohort is considerably better than what the literature would suggest for people of ABI of approximately 40% for all levels of disability. The findings from the present study are also consistent with the RTW rates we found in our two previous RCT's. The present findings provide some initial support for the clinical effectiveness of RF for a sample referred by the Indiana Vocational Rehabilitation Services.

However, the present study has several limitations. Specifically, the sampling method in this study is not traditional, and although our control group was randomized into the control condition, our treatment group was not, therefore potentially adding bias to our study. In addition, some significant differences between the groups at baseline could confound some of the outcome variables, specifically time since injury, age at injury, as well as diagnosis. However, this sample is more representative of a clinical population seen in a State Vocational Rehabilitation agency, and likely better represents an otherwise ignored sector of the population previously underrepresented in clinical trials. Therefore, these findings support the transition from the established RF efficacy into clinical effectiveness.

The present study took place over different economic epochs, which could serve to influence RTW. The recession occurred from 2007 through 2011. Control group data was collected between 2008 and 2013, while data from the treatment group was collected between 2009 and 2012. Therefore, a larger proportion of data collection took place during the recession for the treatment group than the control groups. Therefore, it would seem unlikely that the changes in the economy served as a positive bias for RTW for the treatment group.

Although this study successfully demonstrates the effectiveness of RF, additional established predictors of employment success should be taken into account. For example, Cuthbert and colleagues found that age, race, gender, marital status, rehabilitation payment source, education, pre-injury work status, length of stay, and the disability rating scale (DRS) were significant predictors of employment two years post injury (Cuthbert et al., 2015). Due to our sampling methods, we were unable to use well-known predictors of outcome in our statistical analyses. This exclusion of key predictors likely led to the small effect size of our prediction model. Also, future studies in RF need to consider relationship between pre-injury rates of employment and post-RF employment and study change in occupational type from pre-injury to post-injury. Last, we were not able to evaluate durability or stability of employment for more than 90 days, and given that the disability associated with these injuries was likely chronic, and for some, the level of disability might get worse. This would therefore suggest a need for long-term surveillance to proactively monitor vocational adjustment and stability.

Acknowledgments

The authors would like to acknowledge Peter A. Bisbecos, J.D., former Director of the Division of Disability & Rehabilitative Services, and Kylee B. Hope, J.D., current Director of the Division of Disability & Rehabilitative Services, whose support provided the opportunity to complete the present prospective clinical cohort study. The authors would also like to acknowledge the efforts of Summer Ibarra, Ph.D., Laura C. Trexler, O.T.R., Judy Reuter, and the entire Resource Facilitation team who provided the services to the participations in the present study.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

American Medical Rehabilitation Providers Association, eRehab-data. (2012). Retrieved from https://web2.erehabdata.com/erehabdata/index.jsp

Ben-Yishay, Y., Silver, S. M., Piasetsky, E., & Rattok, J. (1987). Relationship between employability and vocational outcome after intensive holistic cognitive rehabilitation. *The Journal of Head Trauma Rehabilitation*, *2*(1), 35-48.

Bounds, T. A., Schopp, L., Johnstone, B., Unger, C., & Goldman, H. (2003). Gender differences in a sample of vocational rehabilitation clients with TBI. *NeuroRehabilitation*, *18*(3), 189-196.

Brain Injury Association Inc. (2001). *Resource Facilitation: A consensus of principles and best practices to guide program development and operation in brain injury*. Alexandra, VA: Connors, S.H.

Corrigan, J. D., & Hammond, F. M. (2013). Traumatic brain injury as a chronic health condition. *Archives of Physical Medicine and Rehabilitation*, *94*(6), 1199-1201.

Cuthbert, J. P., Harrison-Felix, C., Corrigan, J. D., Bell, J. M., Haarbauer-Krupa, J. K., & Miller, A. C. (2015). Unemployment in the United States after traumatic brain injury for working-age individuals: Prevalence and associated factors 2 years postinjury. *The Journal of Head Trauma Rehabilitation*, *30*(3), 160-174.

Dikmen, S., Machamer, J., & Temkin, N. (1993). Psychosocial outcome in patients with moderate to severe head injury: 2-year follow-up. *Brain Injury*, *7*(2), 113-124.

Dikmen, S. S., Temkin, N. R., Machamer, J. E., Holubkov, A. L., Fraser, R. T., & Winn, H. R. (1994). Employment following traumatic head injuries. *Archives of Neurology*, *51*(2), 177-186.

Fadyl, J. K., & McPherson, K. M. (2009). Approaches to vocational rehabilitation after traumatic brain injury: A review of the evidence. *The Journal of Head Trauma Rehabilitation*, *24*(3), 195-212.

Groswasser, Z., Reider-Groswasser, I. I., Schwab, K., Ommaya, A. K., Pridgen, A., Brown, H. R., . . . & Salazar, A. M. (2002). Quantitative imaging in late TBI. Part II: Cognition and work after closed and penetrating head injury: A report of the Vietnam Head Injury Study. *Brain Injury*, *16*(8), 681-690.

Kolakowsky-Hayner, S. A., & Kishore, R. (1999). Caregiver functioning after traumatic injury. *NeuroRehabilitation*, *13*(1), 27-33.

Kreutzer, J. S., Marwitz, J. H., & Kepler, K. (1992). Traumatic brain injury: Family response and outcome. *Archives of Physical Medicine and Rehabilitation*, *73*(8), 771-778.

Kreutzer, J. S., Gervasio, A. H., & Camplair, P. S. (1994). Primary caregivers' psychological status and family functioning after traumatic brain injury. *Brain Injury*, *8*(3), 197-210.

Malec, J. F., Buffington, A. L., Moessner, A. M., & Degiorgio, L. (2000). A medical/vocational case coordination system for persons with brain injury: An evaluation of employment outcomes. *Archives of Physical Medicine and Rehabilitation*, *81*(8), 1007-1015.

Malec, J. (2005). The Mayo Portland Adaptability Inventory. The Center for Outcome Measurement in Brain Injury. Retrieved July 27, 2017 from http://www.tbims.org/combi/mpai

Malec, J. F., & Moessner, A. M. (2006). Replicated positive results for the VCC model of vocational intervention after ABI within the social model of disability. *Brain Injury*, *20*(3), 227-236.

Prigatano, G. P., Fordyce, D. J., Zeiner, H. K., Roueche, J. R., Pepping, M., & Wood, B. C. (1984). Neuropsychological rehabilitation after closed head injury in young adults. *Journal of Neurology, Neurosurgery* & *Psychiatry*, *47*(5), 505-513.

Trexler, L. E., Trexler, L. C., Malec, J. F., Klyce, D., & Parrott, D. (2010). Prospective randomized controlled trial of resource facilitation on community participation and vocational outcome following brain injury. *The Journal of Head Trauma Rehabilitation*, *25*(6), 440-446.

Trexler, L. E., Parrott, D. R., & Malec, J. F. (2016). Replication of a prospective randomized controlled trial of resource facilitation to improve return to work and school after brain injury. *Archives of Physical Medicine and Rehabilitation*, *97*(2), 204-210.

UDS. (2012). *Uniform Data System for Medical Rehabilitation.* Retrieved from http://www.udsmr.org/Default.aspx

Van Velzen, J. M., Van Bennekom, C. A. M., Edelaar, M. J. A., Sluiter, J. K., & Frings-Dresen, M. H. W. (2009). How many people return to work after acquired brain injury?: A systematic review. *Brain Injury*, *23*(6), 473-488.

Wehman, P., Bricout, J., Targett, P., Fraser, R. T., & Clemmons, D. C. (2000). Supported employment for persons with traumatic brain injury: A guide for implementation. *Traumatic Brain Injury Rehabilitation*, 201-240.

Wehman, P., West, M., Fry, R., Sherron, P., Groah, C., Kreutzer, J., & Sale, P. (1989). Effect of supported employment on the vocational outcomes of persons with traumatic brain injury. *Journal of Applied Behavior Analysis*, *22*(4), 395-405.

Wehman, P., Kregel, J., Keyser-Marcus, L., Sherron-Targett, P., Campbell, L., West, M., & Cifu, D. X. (2003). Supported employment for persons with traumatic brain injury: A preliminary investigation of long-term follow-up costs and program efficiency. *Archives of Physical Medicine and Rehabilitation*, *84*(2), 192-196.

BALL STATE UNIVERSITY
Muncie, Indiana 47306-0325

CENTER FOR BUSINESS AND ECONOMIC RESEARCH
MILLER COLLEGE OF BUSINESS
Phone: 765-285-5926
Fax: 765-285-8024

February 21, 2017

Economic Impact of Resource Facilitation: Workforce Re-entry Following Traumatic Brain Injury

Brandon Patterson, Graduate Research Assistant

Srikant Devaraj, Ph.D., Research Economist and Research Assistant Professor

Michael J. Hicks, Ph.D., George & Frances Ball Distinguished Professor of Economics, Director of Center for Business and Economic Research

Introduction

This research note presents the economic impact of Resource Facilitation (RF) on traumatic brain injury (TBI) patients in Indiana. We focus on the ability of RF to enable patients with a TBI-related disability to reenter the workforce. Using estimates for the impact of RF on the workforce, we then proceed to estimate the potential dollar-impact of RF on wages, fringe benefits, payroll and income taxes, and disability insurance.

Estimation Methods

Job loss due to disability following TBI is not uncommon and is economically costly due to lost wages and workplace productivity. Additional costs such as potential public and private disability insurance payments also accrue TBI related accidents. . A major benefit of RF is the patients' return-to-work, with one study showing that patients treated with RF were 73% more likely to return to work than were patients undergoing standard treatments (Trexler, Parrott and Malec 2016).Here, we attempt to place a dollar value on the economic benefits of RF resulting from this increased return to the workforce.

Research on the number of TBI-related disabilities that are incurred each year is relatively sparse, and the literature doesn't contain an accurate estimate for Indiana. Therefore, we attempt to produce our own estimates of TBI-related disability prevalence in Indiana. We then use these disability estimates to determine the potential economic impact of RF. The first method seeks to estimate the annual incursion of TBI-related disability, while the second method seeks to estimate the aggregate pool of persons disabled by TBI, regardless of when their TBI occurred. In each case, we estimate the number of persons in each of various age groups with a TBI-related disability, use this number to estimate the number of additional persons that would return to work with RF treatment, and then estimate the expected wages, taxes, etc., for these potentially returned workers.

Tables 1 and 2 contain the results of each method. Table 1 shows the approximate age breakdown of TBI-related disabilities, and Table 2 details the estimated economic impact under each method.

Annual Incidence Estimate:

To estimate the annual incidence, we modify the methodology that was used in a previous research note to estimate the number of new cases of TBI-disability per year (Reid, McGeary and Hicks 2011).For this estimate, we use national annual TBI hospitalization incidence of 2.5 million cases from the CDC for 2015 (Centers for Disease Control and Prevention 2015). Based on population weights, we then estimate the number of TBI-related hospitalizations in Indiana to be 2,472 incidence per year. Based on the Selassie, Zaloshnja, Langlois et al. (2008) study, we distribute the 2,472 patients into different age categories. We then estimate the number of new TBI-disabilities incurred each year using the conditional probabilities of disability given hospitalization due to TBI observed (Selassie, et al. 2008). See Table 1, for the distribution of new TBI hospitalization incidence leading to disability by age group.

Using these TBI-disability incidence estimates, we now estimate the potential economic annual impacts of RF treatment on newly TBI-disabled patients. Since we are estimating the effects on those in the labor force, for each age group, we apply the labor force participation rates from Bureau of Labor Statistics to estimate the number of TBI-disability patients who were potentially employed prior to the TBI. The Trexler, Parrott and Malec (2016) study shows the probability of return-to-work with RF for TBI patients was 69%. From the existing literature, they found that the return-to-work probability without RF treatment for TBI patients was 40%. We apply these estimates on the TBI-disability estimates by age group for Indiana. The marginal impact of RF return to work is the number of potential patients returning to work after RF treatment minus the number of patients returning to work without RF treatment. We then estimate this marginal employment impact of RF return to work by age group. We find that 266 patients would additionally benefit from RF treatment by returning to work [i.e., they would not have returned to work without the RF treatment].

We now apply average wages by age group on the RF estimates to find the additional wages of marginal patients who received RF treatment and returned to work, who otherwise would not have returned to work without the treatment. We also estimate the potential fringe benefits of 45.77% that patients who now work would receive (BLS, 2016); payroll taxes of 15.3% for social security and Medicare (SSA, 2017); Federal income tax of 21% (IRS, 2016); and Indiana state tax of 3.3% (Flat tax, 2016).

We also estimate the potential Social Security Disability Insurance (SSDI) savings to the government due to patients returning to work after treatment. Since 30% of workers are covered under short-term disability through work that covers about 70% of wages, we also estimate the additional impact on private disability insurance after deducting the wages that they would have got from SSDI (National Compensation Survey: Employee Benefits in Private Industry in the United States, U.S. Department of Labor, Bureau of Labor Statistics, March 2006). Finally, we attempt to estimate the potential Supplemental Nutrition Assistance Program (SNAP) savings from 30% (assumed) of patients who returned to work after RF treatment and stopped participation in SNAP as a result. We also use the average SNAP household benefit in Indiana of $3,060 for our analysis (IN SNAP, 2016)

The economic impact on wages and benefits alone is estimated to be approximately $17.27 million. The revenues from taxes is about $2.15 million dollars. The potential savings from SSDI is $2.84 million and for private disability insurance is $1.5 million. The potential SNAP savings is about $0.24 million. The findings of this method are shown in Table 2.

Aggregate Lifetime Estimate:

The previous method (annual incidence estimate) accounts for the impact of RF on a single cohort of patients, for a single year. Disabled patients who return to work after RF are likely to continue working beyond a single year period. The cumulative annual effect of RF might be better represented by applying an impact analysis to the pool of all TBI-disabled persons rather than the annual incidence of TBI-disability. In 2015, the CDC reported an estimated pool of 3.2 to 5.3 million persons living with a TBI-related disability (Centers for Disease Control and Prevention 2015). Using the lower bound of this estimate, Indiana's share of the disabled pool is approximately 66,410 persons. See Table 1 last column for cumulative distribution by age group. Using annual TBI incidence by age group (calculated as in the previous method) and CDC mortality estimates by age group, adjusted to reflect increased mortality due to TBI, we simulate a stable state of the disabled population by age group. We then apply our economic impact estimates to the entire pool of TBI-disabled persons to determine the potential long-term impact of RF treatment.

Assuming that all persons in the pool underwent RF as part of a post-TBI treatment, around 7,255 additional persons would return to work, who would otherwise not have returned to work had they not received RF treatment. Accounting for the fact that disabled persons are likely to take a lower-paying job when they return to work, we attempt to provide a lower-bound estimate by assuming that disabled workers would have approximately half the earning power of the average individual. Under this assumption, the estimated annual impact of RF in Indiana is approximately $249.1 million in wages and benefits, $30.97 million in taxes, savings of $80.1 million in reduced disability insurance benefit payments and $6.6 million in SNAP impact. The detailed findings are shown in the last column of Table 2.

The results of the aggregate estimate are more indicative of the long-term annual impact of RF. While it may not be possible to provide retroactive RF for every patient who has ever suffered a TBI-disability, we can view the assumed impact of RF on the entire disabled pool as the potential cumulative annual economic impact of RF if it had historically been administered to all new TBI-disabled patients. Similarly, this cumulative impact demonstrates the potential annual impact of RF treatment after several years of application to new TBI patients.

Table 1: TBI-Related Disabilities per Age Group

	New Incidence	**Cumulative Incidence**
0 to 4	29	177
5 to 9	29	336
10 to 14	29	480
15 to 19	108	1,082
20 to 24	114	1,657
25 to 34	169	4,520
35 to 44	195	5,743
45 to 54	240	7,081
55 to 64	215	7,582
65 to 74	342	8,525
75+	1,002	29,227
Total	**2,472**	**66,410**

Table 2: Estimated Economic Impacts Attributable to RF

	New Incidence	**Aggregate Lifetime Estimate**
Employment	**266**	**7,255**
Wages	$ 11,844,570	**$ 170,875,856**
Fringe Benefits	$ 5,421,260	**$ 78,209,879**
Payroll Tax	$ 829,453	**$ 11,966,111**
Income Tax	$ 1,317,366	**$ 19,005,001**
Federal	$ 1,138,465	$ 16,424,075
State	$ 178,902	$ 2,580,926
Disability Insurance	$ 4,339,316	**$ 80,134,992**
Social Security	$ 2,837,856	$ 80,134,992
Private	$ 1,501,460	(Policy-Specific)
SNAP	$ 244,188	**$ 6,660,090**

Summary

In this research note, we estimate the marginal economic impact of RF treatment by estimating the potential TBI-disabled patients that would return to work after receiving the treatment, who otherwise would not return to work had they not received the treatment. We estimate the impact based on annual incidence and aggregate lifetime incidence. Table 2 summarizes the economic impact of both methods.

To illustrate the potential long-term impact of RF, let us assume that an average-earning 25-year-old suffers from a post-TBI disability. We assume also that this individual had private long-term disability insurance that covers 50% of lost wages until age 65, and that he is one of the patients who is able to return to work after RF treatment, but otherwise would not return to work at all. Assuming that he continues to earn average wages, benefits, etc., until retirement (age 65), the nominal career-total impact of his return to work total at approximately $2.94 million in wages and benefits, $0.80 million in state and federal taxes, $0.69 million in Social Security Disability Insurance payments, and $0.66 million in private disability insurance impact. These impacts are detailed in Table 3.

Table 3: Career Impact of RF for a 25-Year-Old TBI Patient

	RF Impact
Wages	**$ 2,019,270**
Fringe Benefits	**$ 924,220**
Payroll Tax	**$ 308,948**
Income Tax	**$ 490,683**
Federal	$ 424,047
State	$ 66,636
Disability Insurance	**$ 1,354,035**
Social Security	$ 688,800
Private	$ 665,235

Additional Impact

Our estimated economic impacts consider only the benefits related to gainful employment and are very conservative because we do not include the induced effects of those patients receiving the wages i.e., the household spending on goods and services would stimulate the economy. We also do not include potential unemployment benefits payments that would have been avoided for some patients. We do not include the potential re-admission hospital costs to Medicare/Medicaid of such patients. Many RF patients who do not return to work volunteer in the community in lieu of work (Trexler, Parrott and Malec 2016). The economic benefits from this unpaid community involvement are not considered here, but likely have both economic impact to the community, and quality-of-life improvement for the patient. Further investigation into this particular RF outcome is encouraged.

Further, in Indiana in 2012, there were 191 total Medicaid waivers related to TBI, for a total of approximately $4.5 million in benefits. Even if we assume the TBI waiver population is uniformly distributed among the TBI population, RF could mitigate a portion of the waivers expenditure, resulting in a cumulative annual economic benefit of at most $2.3 million.

The study comes with certain limitations as well. Quality state-level TBI data does not exist or is not readily available. Recent estimates of the annual incursion of TBI-related disabilities are not available. The impact of TBI-disability on future earning potential is unclear. In each of these cases, we have used simplifying assumptions to estimate these values based on other less detailed data. More detailed data would allow several assumptions to be removed from our calculations, thereby improving the accuracy of our estimates.

Applying RF treatment to the entire cohort of patients with a TBI-disability every year may not be feasible. The differential impact of RF on return-to-work is estimated to be about 29%. Approximately 40% of TBI-disabled patients would reenter the workforce without RF, while another 31% will fail to return to work even with RF treatment. This implies that the economic impact of RF is concentrated among a subset of the total TBI-disabled population. Table 4 demonstrates that wages are concentrated among the better educated, and to a lesser extent, the male populations. If treating all TBI-disabled patients is not feasible, using simple classification tools such as Table 4 along with the patient’s expected remaining working years could help identify patients with the greatest potential for economic impact due to RF. Further research could be conducted to better identify the patients who would only return to work with the assistance provided by RF treatment.

Table 4: Median Earnings by Education Level and Gender

	Total	Male	Female
Less than high school graduate	$20,361	$23,668	$15,510
High school graduate (includes equivalency)	$28,043	$33,235	$22,345
Some college or associate's degree	$33,820	$41,407	$28,285
Bachelor's degree	$50,595	$61,589	$41,763
Graduate or professional degree	$66,857	$84,006	$56,181
Total	$36,231	$42,106	$30,602

References

Centers for Disease Control and Prevention. 2015. "Report to Congress on Traumatic Brain Injury in the United States: Epidemiology and Rehabilitation." Atlanta, GA: National Center for Injury Prevention and Control; Division of Unintentional Injury Prevention.

Reid, Ian, Kerry A. McGeary, and Michael J. Hicks. 2011. "Potential Economic Impact of Resource Facilitation for Post-Traumatic Brain Injury Workforce Re-Assimilation." Ball State University Center for Business and Economic Research.

Selassie, Anbesaw W., Eduard Zaloshnja, Jean A. Langlois, Ted Miller, Paul Jones, and Claudia Steiner. 2008. "Incidence of Long-term Disability Following Traumatic Brain Injury Hospitalization, United States, 2003." *The Journal of head trauma rehabilitation 23.2* 123-131.

Trexler, Lance E., Devan R. Parrott, and James F. Malec. 2016. "Replication of a Prospective Randomized Controlled Trial of Resource Facilitation to Improve Return to Work and School After Brain Injury." *Archives of Physical Medicine and Rehabilitation 97.2* 204-210.

Calculation Data Sources

Centers for Disease Control and Prevention – 2007 Worktable 23R, mortality by 10-year age groups

2015 Report to Congress (listed as a reference) – annual TBI cases, TBI hospitalization chance

American Community Survey – 2015 United States population, 2015 Indiana population

Selassie (from references) – TBI hospitalization age distributions, disability probabilities by age group

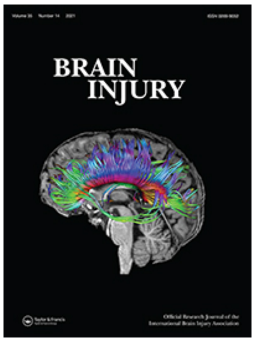
Bureau of Labor Statistics – 2014 labor force participation rates by age group

Quarterly Workforce Indicators – average 2015 monthly wage by age group (all quarters)

Social Security Administration – 2017 Payroll Tax Rate

Internal Revenue Service – Average 2016 Federal Income Tax Rate

IN Tax Code – 2016 Flat Income Tax Rate



Taylor & Francis
Taylor & Francis Group

Brain Injury

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ibij20

The impact of resource facilitation on recidivism for individuals with traumatic brain injury: A pilot, non-randomized controlled study

Lance E. Trexler & Devan Parrott

To cite this article: Lance E. Trexler & Devan Parrott (2022): The impact of resource facilitation on recidivism for individuals with traumatic brain injury: A pilot, non-randomized controlled study, Brain Injury, DOI: 10.1080/02699052.2022.2051207

To link to this article: https://doi.org/10.1080/02699052.2022.2051207

BRAIN INJURY
https://doi.org/10.1080/02699052.2022.2051207

Taylor & Francis
Taylor & Francis Group

The impact of resource facilitation on recidivism for individuals with traumatic brain injury: A pilot, non-randomized controlled study

Lance E. Trexler[a] and Devan Parrott[b]

[a]Department of Physical Medicine and Rehabilitation, Indiana University School of Medicine, Indianapolis, Indiana, United States; [b]Research, Training and Outcomes Center for Brain Injury, Rehabilitation Hospital of Indiana, Indianapolis, Indiana, United States

ABSTRACT

Objective: Research has shown that as many as 60% of adults in the criminal justice system have a history of traumatic brain injury (TBI), but the examination of effective interventions to reduce recidivism has only just begun. The present study explored the extent to which resource facilitation (RF) may decrease recidivism among those individuals with TBI.

Methods: Over a 2-year period, a prospective, non-randomized controlled study was conducted that included 1,504 justice-involved individuals exiting the Indiana Department of Corrections (IDOC). Participants were screened for a history of TBI as they entered parole or community corrections, with 211 (14%) offenders screening positive for moderate-to-severe TBI. Thirty-one of the 211 offenders offered RF chose to participate in the intervention, while 180 declined and served as the comparison group.

Results: Participants in RF were found to recidivate significantly less often at 6 and 12 months post-release when looking at rearrests or return to incarceration combined between the two groups.

Conclusion: Our findings suggest that the increased risk for reincarceration in those individuals with TBI could be mitigated by the use of RF.

ARTICLE HISTORY
Received 11 August 2021
Revised 24 February 2022
Accepted 6 March 2022

KEYWORDS
Adolescence; adults; recidivism; resource facilitation; traumatic brain injury

Introduction

An awareness of the relationship between a lifetime exposure to traumatic brain injury (TBI) and incarceration has evolved, particularly over the last decade. The estimated prevalence of TBI among offenders has varied as a function of the sampling methods utilized and how the presence of a TBI was defined, with a meta-analysis of 20 epidemiological studies (1), finding that the estimated prevalence was 60.25% for offenders compared to between 21% and 24% for the general population (2,3). A recent study conducted neuropsychological testing after screening for exposure to TBI (4) and found that, among the 158 incarcerated adults, 120 (76%) screened positive for lifetime exposure and, of the 88 who received neuropsychological testing, 75% demonstrated some level of impairment that ranged from mild (45%), to moderate (28%), to severe (28%). For those screening positive, it was found that they had an average of 3.8 events during their lives that could have resulted in a brain injury. The majority of these events occurred when they were children.

TBI during childhood and adolescence may significantly increase the vulnerability to engagement with the juvenile/criminal justice systems. When TBI occurs in children or adolescents, the available research suggests that they may be put at risk for persistent and more violent offending throughout their lifetime (5,6). Moreover, in a study of 508 adolescents hospitalized for psychiatric reasons (7), it was discovered that TBI during childhood and adolescence increased the risk of any criminality 6.8 times, the risk of diagnosis of a conduct disorder 5.7 times, and the risk of concomitant criminality and conduct disorder 18.7 times. It has been suggested that childhood or adolescent TBI results in a failure to develop brain networks responsible for the management of adaptive social behavior and emotional self-regulation. This leaves them vulnerable to impulsive and aggressive behavior, resulting in engagement with the juvenile justice system (8) and criminal persistence (9).

Supporting the hypothesis that TBI may contribute to criminal persistence, several studies have found that those with TBI are at greater risk for recidivism. In a study of 151 males released from prison, it was shown that 35% of those with mild-to-severe TBI had recidivated compared to 26% without TBI at 6 months' post-release (10). This discrepancy was found to persist at 12 months' post-release, in which 48% of those with TBI were reincarcerated compared to 37% of those without TBI. In this study, it was also found that, when controlling for age, race/ethnicity, type of offense, and education, those with TBI had significantly higher rates of recidivism. Another study of lifetime exposure to moderate-to-severe TBI revealed that 8.7% recidivated for those with TBI at 6 months and 17.4% at 12 months and were nearly twice as likely to recidivate than those without TBI (11). Methodological inconsistencies between these studies likely explain the variability in recidivism rates, including when the screening for lifetime exposure to TBI occurred (entry to prison compared to community reentry), who administered the screening instrument (researcher vs probation officer), and the severity of possible TBI.

CONTACT Lance E. Trexler ltrexler@iu.edu Department of Physical Medicine and Rehabilitation, , Indiana University School of Medicine, 355 West 16th Street, Goodman Hall, Suite 4300, Indianapolis, IN 46202, United States

Predictors of incarceration and recidivism after TBI have been shown to include a variety of pre-injury factors, and those who were male, unmarried, and young were found to be more likely to have post-TBI arrest, as well as those who had a history of significant substance abuse (12). A history of mental health treatment for both veterans (13) and civilians (14) has also found to predict arrest after TBI. TBI has also been shown to increase the risk of reoffending (15). Ethnic and racial variables are also predictive of both TBI incidence and arrest. Specifically, it has been found that Black people are more likely to have TBI (16), and in a recent TBIMS study examining the extent to which racial and ethnic disparities affect arrest probabilities, it was found that Asian individuals had the lowest arrest probability in comparison to Native American and Black individuals who were found to have the highest arrest probability trajectories (17). In a 2010 comprehensive review of literature, it was found that minorities with TBI had significantly poorer outcomes across all domains, including treatment and neuropsychological outcome, employment and productivity, community integration and functional outcome, marital status, neurobehavioral status, and quality/satisfaction with life as compared to Whites (18).

There has been only one published intervention study seeking to prevent recidivism for those with TBI. In an uncontrolled descriptive cohort study (4), 44 previously incarcerated adults with an average of four TBIs (75% of which were sustained during childhood) who demonstrated neurocognitive impairment on testing received resource facilitation (RF) for an average of 12 months' post-release. RF is an evidence-based intervention that has been described as a process of identifying service needs and providing access to services that meet those needs. For those participants who received RF, almost two-thirds became engaged in productive activity (work, volunteering, and training), and 50% became competitively employed. The rate of recidivism was found to be 17% at mostly 1-year post-release; although there is variability in the reported rates of recidivism for people with TBI, these findings are promising.

Previous research has shown that RF significantly improves vocational and educational outcomes and decreases the level of disability associated with TBI ([19–21]). The process of providing RF includes conducting an initial evaluation from which to develop a person-centered plan to assist the person with lived experience of brain injury and their family access instrumental supports, social resources, and health care and rehabilitation services. A variety of models exist for RF, but for those which have evidence, the process is guided by a team of brain injury specialists, including a neuropsychologist, a clinical rehabilitation therapist, and other health-care professionals trained in RF. The typical duration of RF has been 9 to 16 months with at least monthly team conferences to review progress and goal attainment. RF is unique to TBI and different from most models of case management, which are usually specific to a particular domain (e.g., social, medical, or vocational), in contrast to RF, which addresses any domain for which the person with TBI or their families have a need. The present pilot study was conducted to specifically examine whether RF could decrease recidivism for justice-involved people with TBI exiting a correctional facility. It was hypothesized that participants with TBI receiving RF would demonstrate lower reincarceration rates than participants with TBI who did not receive RF. It was further hypothesized that adding a variable indicating participation in RF services would improve a binomial logistic regression model that consisted of the available demographics shown to impact recidivism in this TBI sample (age, race, years of education, and employment status at the time of initial arrest).

Materials and methods

Participants

Participants in this study were screened after being released from prison and as they were entering parole and a community corrections program administered by the Indiana Department of Corrections (IDOC). Those participants screening positive for moderate-to-severe TBI, consenting to be included in the study and aged 18 years and older, were included in the study. Screening was completed between June 2015 and June 2017. All previously incarcerated individuals who screened positive for TBI during this 2-year period were followed electronically as a cohort by DOC, and outcome data were provided at the study's conclusion.

Throughout the 2 years of screening, 1,504 formerly incarcerated individuals were screened for a history of TBI, with 211 (14%) indicating moderate-to-severe TBI. All participants who screened positive for moderate-to-severe TBI were offered RF. Those consenting to participate in RF served as the treatment group, and those who declined participation in RF comprised the comparison group. Human subjects research approval was granted by the local institutional review board, and participants provided informed consent.

Measures

Screening for history of TBI was completed using the Ohio State University Traumatic Brain Injury Identification (OSU-TBI-ID) method to determine lifetime exposure to moderate or severe TBI. Screening was completed by a Master's level psychologist who was trained on the use of the OSU-TBI-ID by the study investigators. The OSU-TBI-ID consists of a structured interview designed to identify a history of TBI, as well as basic injury-related variables, including the duration of loss of consciousness and age at injury for each reported injury (22,23). The OSU-TBI-ID shows strong reliability and validity across administrators and samples.

Recidivism data, which were based on rearrests and returns to IDOC, were collected electronically on all screened offenders at 6- and 12-months' post-release during the project and were provided directly from IDOC. Both variables were dichotomous and indicated the presence of any rearrests or IDOC incarceration within the indicated time period. Therefore, any arrests or incarceration within the 6-month period would automatically be included in the 12-month period as well.

RF treatment

Participants in the RF intervention group received one of the two service levels, defined as "RF" and "Modified RF." The study's initial design consisted of all participants receiving the full RF model as described in the Indiana RF Best Practices Manual (24) that was used in the previous research ([19–21]). In this model, participants received a comprehensive evaluation and RF services of 6–12 months' duration as well as access to a variety of TBI-specific therapies, such as cognitive rehabilitation or group coping skills interventions. Access to these services was dependent on authorization from Indiana Vocational Rehabilitation Services (IVRS). IVRS experienced a significant staff shortage during the first year of the project, however, and also implemented an order of selection process that resulted in long delays (up to 6 months) for initial evaluation. As a consequence, fewer study participants obtained access to RF services.

Additionally, clients under supervision of parole or community corrections were required to obtain employment as soon as possible after release. This often meant working multiple low-skill, low-wage jobs that made them ineligible for IVRS services. To address the restricted access to RF services, a "Modified RF" program was implemented that incorporated a core set of the fundamental elements of the RF services in addition to a modified initial evaluation. An itemization of the differences between the two levels of RF treatment is displayed in Figure 1. Both groups received individualized service navigation to TBI, instrumental, and community resources, but those in RF were typically referred to community providers for TBI individual and group therapies to which the Modified RF group did not have access. To at least partially address cognitive and behavioral impairments and equalize the treatment received, a TBI Education Group and a TBI Life Skills Group for the Modified RF group were provided. It was not possible to reliably collect data on either of these variables in this setting, but those in RF likely received approximately 8–10 hours of services a week for approximately 6–12 months, while those in the Modified RF group received approximately 4–8 hours of services a week for 3–6 months, essentially half of the duration and intensity of the model used in the previous research.

RF	Modified RF
Comprehensive Evaluation and Education	**Abbreviated Evaluation and Education**
a) OSU-TBI-ID b) RF intake with client and family c) Evaluation (8 hours) of: Cognitive and neurobehavioral functions Substance abuse Family and social support Level of disability Pain Mobility Personality and emotional functioning Vocational preferences and barriers d) Local support network community assessment (available community resources for that individual based on needs identified in the evaluation) e) RF team case conference f) Comprehensive report and plan of care g) Person with TBI and family education about TBI and its effects	a) OSU screening b) RF intake with client c) Evaluation of: Cognitive and neurobehavioral functions Substance abuse Level of disability d) RF team case conference e) TBI wallet cards containing information about their injury and summary results of the evaluation were given to each client f) Person with TBI and family education about TBI and its effects
RF Services	**RF Services**
a) Individual community-based RF contact every 2 weeks on average for 12 months: facilitating resource acquisition, providing education to client, family, and providers, ongoing monitoring of success of resources, modification to plan as needed, collaboration and integration of treatment plans b) Navigation to multiple community services and supports (ie, housing, medical services, brain injury services, support groups, others) and management-coordination of services for comorbidities and co-occurring conditions (eg, mental health, substance abuse) c) Monthly RF team case conference and report documentation d) Collaboration/education with employment specialist/job coach/prospective employer e) Vocational placement services for 90-day vocational stabilization f) At close of 90 days – RF review and stabilization of resources, satisfaction surveys, program evaluation data collection	a) Individual community-based RF frequency and duration as possible to address TBI and instrumental needs b) Navigation to multiple community services and supports (eg, housing, medical services, brain injury services, support groups, others) and management-coordination of services for comorbidities and co-occurring conditions (eg, mental health, substance abuse) c) Monthly RF team case conference and report documentation d) TBI Education Group (1/week) e) TBI Life Skills Group (1/week) f) TBI notebooks containing sections for medications, medical providers, employment, and TBI information were given to each client g) Possible referral to IVRS and intake attended by client and RF

Figure 1. Six- and 12-month measures of recidivism for the RF treatment group vs. the non-RF comparison group. RF: resource facilitation.

Both RF treatment and control group participants also received transitional services from the community reentry program from which they were recruited. These services included family reunification, transitional housing, substance abuse groups, education, emergency assistance (e.g., bus tickets, food, housing, etc.), and assistance with job placement.

Analyses

Fisher's exact test was used to test the primary hypothesis that offenders participating in RF would demonstrate decreased recidivism rates. To test the impact of RF on outcomes, hierarchical logistic regression was used to determine if the addition of RF treatment improved the prediction of recidivism over key demographic variables alone. During logistic regression modeling, linearity of the continuous independent variables with respect to the logit of the dependent variable was assessed using the Box-Tidwell procedure with a Bonferroni correction. All continuous independent variables were found to be linearly related to the logit of the dependent variable. Outliers were defined as cases with standardized residuals less than ±2, and no outliers were detected.

Results

Sample

Of the 211 formerly incarcerated individuals who screened positive for lifetime exposure to moderate-to-severe TBI, 31 consented and participated in RF intervention. Therefore, our final study sample consisted of a treatment group sample size of 31 and a comparison group of 180. Participant demographics are presented in Table 1.

The RF treatment groups comprised 31 justice-involved participants: 8 in RF and 23 in Modified RF. Because of the small sample sizes, data in the two RF interventions were combined and considered "RF treatment." Further subanalyses to examine potential impacts of treatment intensity on outcome were not conducted. Demographic information for those participating in the different levels of RF is provided in Table 2.

Table 1. Participant demographics.

	Treatment group (RF)	Comparison group (no RF)
	n = 31	*n* = 180
Age, mean (SD), years	40.10 (12.10)	39.29 (10.78)
Years of education, mean (SD)	10.90 (2.04)	10.78 (1.95)
Female (%)	0 (0)	8 (4.4)
Race	14 (47)	83 (46.11)
White, *n* (%)	16 (53)	93 (51.67)
Black, *n* (%)	1 (3.33)	5 (2.78)
Other, *n* (%)		
Employed at the time of arrest, *n* (%)	12 (40)	75 (41.67)
Injury severity	21 (68%)	131 (72.78%)
Moderate	8 (26%)	48 (26.67%)
Severe		
Age at first injury, mean (SD), years	23.00 (12.59)	19.70 (9.88)

RF: resource facilitation.

Table 2. Treatment group demographics.

	RF	Modified RF
	n = 8	*n* = 23
Age, mean (SD), years	39.13 (13.20)	40.43 (11.98)
Years of education, mean (SD)	11.88 (1.55)	10.57 (2.11)
Female (%)	0 (0)	0 (0)
Race	4 (50)	10 (43.48)
White, *n* (%)	3 (37.5)	13 (56.52)
Black, *n* (%)	1 (12.5)	0 (0)
Other, *n* (%)		
Employed at time of arrest, *n* (%)	2 (25)	10 (43.48)
Injury severity	5 (62.5%)	16 (69.57%)
Moderate	2 (25%)	6 (26.09%)
Severe		
Age at first injury, mean (SD), years	22.14 (17.99)	23.27 (10.89)

RF: resource facilitation.

No significant differences were found when comparing demographic information between the RF and non-treatment groups or between the participants in each of the RF treatment groups ($p > 0.05$).

Rearrests and return to incarceration

At both 6 and 12 months, those participants who received RF were found to have fewer rearrests and incarcerations than those who did not receive RF (see Figure 2).

Of the 180 offenders with TBI not participating in RF, 28 (16%) were arrested within 6 months of release, and 47 (26%) were arrested within 12 months. Of the 31 RF participants, only one participant (3%) was arrested within 6 months, and five (16%) were arrested within 12 months. The difference in proportions of rearrests at 6 months was significantly different, as assessed by Fisher's exact test ($p = 0.048$) but not at 12 months ($p = 0.168$; see Figure 2).

Of the 180 offenders with TBI not participating in RF, 46 (26%) returned to IDOC within 6 months, and 67 (37%) returned to IDOC within 12 months. Of the 31 RF participants, three (10%) returned to IDOC within 6 months, and seven (23%) returned to IDOC within 12 months. The difference in proportions of offenders returning to incarceration at 6 months was significantly different, as assessed by Fisher's exact test ($p = 0.037$) but not at 12 months ($p = 0.082$).

It should be noted that some participants are counted as returning to incarceration as well as indicating a positive arrest history; however, not all cases returning to IDOC had arrests listed as well. Therefore, the data were combined across the two recidivism variables to investigate the potential impact of RF on arrest and incarceration risk. Of the 180 offenders with TBI not participating in RF, 65 (36%) were arrested or returned to IDOC within 6 months, and 95 (53%) were arrested or returned to IDOC within 12 months. Of the 31 RF participants, 4 (13%) were arrested or returned to IDOC within 6 months, and 10 (32%) returned to IDOC within 12 months. The difference in proportions was significantly different between the two groups, as assessed by Fisher's exact test at the 6-month epoch ($p = 0.007$) as well as at 12 months ($p = 0.027$).

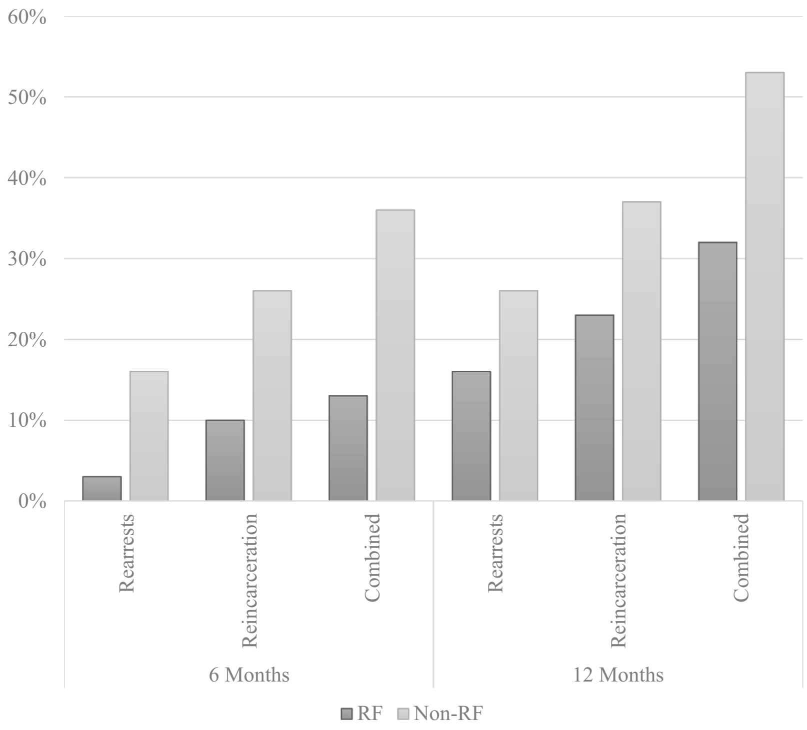


Figure 2. Levels of provided RF services. IVRS: Indiana Vocational Rehabilitation Services; OSU: Ohio State University; OSU-TBI-ID: Ohio State University Traumatic Brain Injury Identification Method; RF: resource facilitation; TBI: traumatic brain injury.

Table 3. Logistic regression models examining likelihood of recidivism.

	b	SE	Wald	*df*	*p*-Value	Odds ratio	95% CI for odds ratio	
							Lower	Upper
Model 1. Likelihood of recidivism in TBI sample based on key demographics (*n* = 211)								
Age	−0.019	0.013	2.171	1	0.141	0.981	0.957	1.006
Employment	−0.133	0.289	0.213	1	0.644	0.875	0.497	1.541
Education	−0.043	0.073	0.338	1	0.561	0.958	0.830	1.106
Race	0.123	0.286	0.186	1	0.667	1.131	0.645	1.984
Constant	1.179	0.910	1.679	1	0.195	3.250		
Model 2. Likelihood of recidivism based on RF participation (*n* = 211)								
Age	−0.019	0.013	2.108	1	0.147	0.981	0.956	1.007
Employment	−0.158	0.291	0.294	1	0.588	0.854	0.483	1.511
Education	−0.040	0.074	0.292	1	0.589	0.961	0.831	1.111
Race	0.128	0.289	0.197	1	0.657	1.137	0.646	2.002
RF participation	0.820	0.416	3.892	1	0.049	2.270	1.005	5.126
Constant	0.444	0.990	0.202	1	0.653	1.560		

RF: resource facilitation; TBI: traumatic brain injury.
Note. Race used White as the indicator variable; RF participation is not participating compared to participation.

An initial model predicting recidivism with key demographics was not statistically significant (χ^2 (4) = 2.94, p = 0.568) (see Table 3). Adding participation in RF services to the model, likewise, did not produce a significant model (χ^2 (5) = 7.216, p = 0.205), although the main effect of RF participation was significant (p = 0.049).

As a post hoc analysis, exploratory regression modeling was completed to examine the impact of various predictors of recidivism in the TBI population. Backward selection was used to ascertain the effects of RF participation while accounting for the impact of available demographics (age, race, years of education, and employment status at the time of initial arrest). Interestingly, the final logistic regression model was reduced to a single independent variable: participation in RF. This model was statistically significant (χ^2 (1) = 4.31, p = 0.038) but only explained 2.7% (Nagelkerke R^2) of the variance in incarceration and arrests and correctly classified 55% of cases, as noted in Table 4. The final model indicates that offenders with TBI in this sample who did not participate in RF demonstrated odds to recidivate that were more than twice as high as those who participated (see Table 5).

Discussion

Previous research has demonstrated considerable variability in the rate of recidivism following TBI, from 17% to 48% at 1-year post-release for the studies cited herein, although those with TBI

Table 4. Hierarchical multiple logistic regression model selection.

	Return to incarceration and arrest									
	Model 1		Model 2		Model 3		Model 4		Model 5	
	b	OR	b	OR	b	OR	b	OR	b	OR
RF participation	**0.820***	2.270	**0.824***	2.280	**0.828***	2.288	**0.826***	2.285	**0.832***	2.298
Age	−0.019	0.981	−0.019	0.981	−0.019	0.981	−0.018	0.982		
Employment	−0.158	0.854	−0.172	0.842	−0.189	0.827				
Education	−0.040	0.961	−0.034	0.966						
Race	0.128	1.137								
Constant	1.264	3.541	1.269	3.557	0.926	2.525	0.816	2.262	0.090	1.094
χ^2 (*df*)		7.216 (5)		7.019 (4)		6.797 (3)		6.360 (2)*		4.306 (1)*
Nagelkerke R^2		0.045		0.044		0.043		0.040		0.027
Correctly classified		61.2%		61.7%		58.9%		58.9%	54.5%	

RF: resource facilitation.

Note. *$p < 0.05$. Race used White as the indicator variable; RF participation is not participating compared to participation.

Table 5. Likelihood of recidivism based on participation in RF.

Logistic regression predicting likelihood of recidivism based on RF participation (*n* = 211)

	b	SE	Wald	*df*	*p*-Value	Odds ratio	95% CI for odds ratio	
							Lower	Upper
Step 1								
Age	−0.019	0.013	2.108	1	0.147	0.981	0.956	1.007
Employment	−0.158	0.291	0.294	1	0.588	0.854	0.483	1.511
Education	−0.040	0.074	0.292	1	0.589	0.961	0.831	1.111
Race	0.128	0.289	0.197	1	0.657	1.137	0.646	2.002
RF participation	0.820	0.416	3.892	1	0.049	2.270	1.005	5.126
Constant	0.444	0.990	0.202	1	0.653	1.560		
Step 5								
RF participation	0.832	0.412	4.068	1	0.044	2.298	1.024	5.157
Constant	−0.742	0.384	3.729	1	0.053	0.476		

RF: resource facilitation.

Note. Race used White as the indicator variable; RF participation is not participating compared to participation.

consistently recidivate more often than those without lifetime exposure to TBI. In this respect, the present data corroborate these previous findings. Efforts to decrease recidivism for those with TBI have just begun, with very preliminary and promising results.

The overall finding of the present study is that those justice-involved participants with TBI who received RF had fewer rearrests and reincarceration, significantly so at 6 months when instances of rearrest or reincarceration were analyzed separately. When these two measures of recidivism were combined, however, the advantage for the RF group was clearly found to be significant at both 6 and 12 months. Those participants with TBI who did not receive RF demonstrated 2.27 times higher odds of either rearrest or reincarceration. Previous research has shown that, at least for adolescents, preventing recidivism would result in a savings of \$2.6 to \$5.3 million per person when including social costs, lost opportunity costs, and costs to victims (25,26). In the current study, we found a 21% reduction in recidivism for the RF group, so if RF was to prevent recidivism for hypothetical 100 people with lived experience of TBI, 32 people would have “saved” 21 people from reincarceration, resulting in a savings of \$54.6 to \$111.3 million.

This study also provided opportunities and challenges from clinical as well as system perspectives. It was quite remarkable, clinically, how few of the participants screening positive for moderate-to-severe TBI were aware that they had a brain injury, let alone understood the implications of having a brain injury. As their awareness emerged through RF, their emotional reactions to this awareness were quite striking and sometimes intense, particularly if their impairments played a role in the reason for their incarceration. For these reasons, intervention research with this population should include clinical protocols for managing these reactions. It was also clinically noteworthy that many of the participants were very committed to participating, especially in group interventions where TBI education and strategies for accommodating or managing TBI-related symptoms were provided. In fact, group size grew from 5 to 6 to more than 20 because the participants did not want to stop attending, even when most of them had to walk almost 3 miles during the winter to get to the community reentry facility.

Because those who are in transition from incarceration to parole, they have an immediate mandate to become gainfully employed. This mandate had a very significant impact on our ability to recruit participants. It is recommended that for future research efforts, the recruitment, the initial assessment, and education about the TBI and its effects should be conducted prerelease from incarceration so that the persons with the TBI understand the potential relevance and importance of their TBI history for successful community reentry and reincarceration avoidance. It would also potentially be helpful to attempt to contact interested family to include them in the education about TBI and its effects.

Researching a TBI intervention in the community-based criminal justice system was incredibly complex and filled with multiple obstacles. The pervasive disconnect between health and rehabilitation, criminal justice, and vocational and employment systems leaves those with TBI in a position of attempting to reenter the community with cognitive and behavioral impairments (for which they had not received treatment) and navigate between these systems. For example, participants with TBI wanted to access services for their TBI but did not have health insurance. When they were provided access to transportation services to apply for health insurance, they forgot the date and time. These barriers and systemic disconnect not only affected the participants’ ability to engage in RF, but they also negatively affected the clinical and research teams' ability to sustain access to the participants. Attitudinal barriers within the criminal justice system were also pervasive, often affecting providers' willingness to collaborate with the study. Health and rehabilitation personnel, however, are sometimes naive about the complexity of criminogenic behavior and its determinants. This research also requires an understanding of both the criminal justice and health and rehabilitation systems, as well as their associated terminologies, both of which were challenges in conducting the present study.

Limitations

Group assignment was not random. The sample size is small, particularly with respect to those receiving RF. Only 31 of 211 who were offered RF based on the results of TBI screening chose to participate. Although there were no demographic differences between the groups for the limited number of measures collected, it is entirely plausible that unmeasured variables, such as level of awareness, extent of cognitive impairment, degree and type of psychiatric comorbidities, or personality characteristics that motivated them to participate in RF, may have accounted for their decreased recidivism. Further, it should be noted that over 50% of our sample was Black, and it could be the case that treatment outcomes varied as a function of race. Future studies should examine racial and ethnic differences in RF outcomes. Also, while the RF participants received largely similar domains of intervention (e.g., TBI individual and group interventions, service navigation, and TBI education), two different levels of intensity and duration of RF were used in this study. Although it could be the case that the holistic model employed in the RF model used in the research is why positive results have been obtained, the active ingredients of RF have not been studied, and this represents a significant opportunity for further research. The finding of decreased recidivism for the RF intervention group is encouraging, given that only approximately one-third of the RF participants received the original RF model.

Conclusions

These preliminary data suggest that RF could mitigate the increased risk for reincarceration for those with TBI, and research should control for the intensity, duration, and specific inclusive services to better understand what, overall, makes RF effective. Future studies should recruit and enroll incarcerated participants soon before their release to promote their engagement in RF, developing post-release plans for TBI-informed community reentry services and supports that can be combined with their efforts to obtain employment. Finally, research should systematically examine the variables known to affect recidivism, including psychiatric disorders, learning disabilities, and level of cognitive impairment, to determine the relationship between outcome and the use of RF.

Disclosure statement

The authors declare no conflict of interest

Funding

This work was conducted with support from the US Department of Health & Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau Traumatic Brain Injury Implementation Partnership Grant (Grant Number H21MC26914). The contents of this publication do not necessarily represent the policy of the Health Resources and Services Administration and do not assume endorsement by the Federal Government.

References

1. Shiroma EJ, Ferguson PL, Pickelsimer EE.Prevalence of traumatic brain injury in an offender population: a meta-analysis. J Head Trauma Rehabil. 2012;27(3):E1–10.doi:10.1097/HTR.0b013e3182571c14.
2. Corrigan JD, Yang J, Singichetti B, Manchester K, Bogner J. Lifetime prevalence of traumatic brain injury with loss of consciousness. Inj Prev. 2018;24(6):396–404.doi:10.1136/injuryprev-2017-042371.
3. Whiteneck GG, Cuthbert JP, Corrigan JD, Bogner JA.Prevalence of self-reported lifetime history of traumatic brain injury and associated disability: a statewide population-based survey. J Head Trauma Rehabil. 2016;31(1):E55–62.doi:10.1097/HTR.0000000000000140.
4. Nagele D, Vaccaro M, Schmidt MJ, Keating D.Brain injury in an offender population: implications for reentry and community transition. J Offender Rehabil. 2018;57(8):562–85.doi:10.1080/10509674.2018.1549178.
5. León-Carrión J, Ramos FJ.Blows to the head during development can predispose to violent criminal behaviour: rehabilitation of consequences of head injury is a measure for crime prevention. Brain Inj. 2003;17(3):207–16.doi:10.1080/0269905021000010249.
6. Gordon WA, Spielman LA, Hahn-Ketter AE, Sy KTL.The relationship between traumatic brain injury and criminality in juvenile offenders. J Head Trauma Rehabil. 2017;32(6):393–403. doi:10.1097/HTR.0000000000000274.
7. Luukkainen S, Riala K, Laukkanen M, Hakko H, Räsänen P. Association of traumatic brain injury with criminality in adolescent psychiatric inpatients from Northern Finland. Psychiatry Res. 2012;200(2–3):767–72.doi:10.1016/j.psychres.2012.04.018.
8. Williams WH, Chitsabesan P, Fazel S, McMillan T, Hughes N, Parsonage M, Tonks J . Traumatic brain injury: a potential cause of violent crime? Lancet Psychiatry. 2018;5(10):836–44. doi:10.1016/S2215-0366(18)30062-2.
9. Schwartz JA. A longitudinal assessment of head injuries as a source of acquired neuropsychological deficits and the implications for criminal persistence. Justice Q. 2021;38(2):196–223.doi:10.1080/07418825.2019.1599044.
10. Ray B, Richardson NJ. Traumatic brain injury and recidivism among returning inmates. Crim Justice Behav. 2017;44(3):472–86.doi:10.1177/0093854816686631.
11. Parrott DR, Trexler LE. Traumatic brain injury in Indiana's correctional system: prevalence and recidivism. J Correctional Healthcare In-Process.
12. Elbogen EB, Wolfe JR, Cueva M, Sullivan C, Johnson J. Longitudinal predictors of criminal arrest after traumatic brain injury: results from the Traumatic Brain Injury Model System National Database. J Head Trauma Rehabil. 2015;30(5):E3–E13. doi:10.1097/HTR.0000000000000083.
13. Miles SR, Brenner LA, Neumann D, Hammond FM, Ropacki S, Tang X, Nakase-Richardson R, Smith A, Nakase-Richardson R. Posttraumatic stress disorder symptoms contribute to staff perceived irritability, anger, and aggression after TBI in a longitudinal veteran cohort: a VA TBI Model Systems study. Arch Phys Med Rehabil. 2020;101(1):81–88.doi:10.1016/j.apmr.2019.07.018.
14. Moore E, Indig D, Haysom L. 2014. Traumatic brain injury, mental health, substance use, and offending among incarcerated young people. J Head Trauma Rehabil. 29(3):239–47. doi:10.1097/htr.0b013e31828f9876

15. Williams WH, Mewse AJ, Tonks J, Mills S, Burgess CN, Cordan G. Traumatic brain injury in a prison population: prevalence and risk for re-offending. Brain Injury. 2010;24(10):1184–88.doi:10.3109/02699052.2010.495697.
16. Langlois J, Rutland-Brown W, Thamas KE. TBI in the US: emergency dept visits, hospitalizations, and deaths. Atlanta GA: Centers for Disease Control and Prevention. National Center for Injury Prevention and Control; 2006.
17. Pugh M Jr. Racial/ethnic disparities in longitudinal trajectories. Of arrest probability after traumatic brain injury; 2021.
18. Arango-Lasprilla JC, Kreutzer JS. Racial and ethnic disparities in functional, psychosocial, and neurobehavioral outcomes after brain injury. J Head Trauma Rehabil. 2010 Mar-Apr;25(2):128–36. doi:10.1097/HTR.0b013e3181d36ca3. PMID: 20234227.
19. Trexler LE, Trexler LC, Malec JF, Klyce D, Parrott D.Prospective randomized controlled trial of resource facilitation on community participation and vocational outcome following brain injury. J Head Trauma Rehabil. 2010;25(6):440–46.doi:10.1097/HTR.0b013e3181d41139.
20. Trexler LE, Parrott DR, Malec JF.Replication of a prospective randomized controlled trial of resource facilitation to improve return to work and school after brain injury. Arch Phys Med Rehabil. 2016;97(2):204–10.doi:10.1016/j.apmr.2015.09.016.
21. Trexler LE, Parrott DR.Models of brain injury vocational rehabilitation: the evidence for resource facilitation from efficacy to effectiveness. J Vocat Rehabil. 2018;49(2):195–203.doi:10.3233/JVR-180965.
22. Corrigan JD, Bogner J.Initial reliability and validity of the Ohio State University TBI Identification Method. J Head Trauma Rehabil. 2007;22(6):318–29.doi:10.1097/01.HTR.0000300227.67748.77.
23. Bogner J, Corrigan JD.Reliability and predictive validity of the Ohio State University TBI identification method with prisoners. J Head Trauma Rehabil. 2009;24(4):279–91.doi:10.1097/HTR.0b013e3181a66356.
24. RF best practices manual. 2014 May 12 [accessed 2021 Jan 19]. https://storage.googleapis.com/wzukusers/user-24484025/documents/5a9718074058ddHjhPt2/RF%20Best%20Practices%20Manual.pdf .
25. Cohen MA.The monetary value of saving a high-risk youth. J Quant Criminol. 1998;14(1):5–33.doi:10.1023/A:1023092324459.
26. Cohen MA, Piquero AR.New evidence on the monetary value of saving a high risk youth. J Quant Criminol. 2009;25(1):25–49. doi:10.1007/s10940-008-9057-3.

Traumatic brain injury in precariously housed persons: Incidence and risks

*Tiffany A. O'Connor,[a,b] William J. Panenka,[b,c] Emily M. Livingston,[a,b] Jacob L. Stubbs,[b,c] Julia Askew,[b,c] Charanveer S. Sahota,[a,b] Samantha J. Feldman,[d] Tari Buchanan,[c] Linwan Xu,[e] X. Joan Hu,[e] Donna J. Lang,[b,f] Melissa L. Woodward,[b,c] Wendy Loken Thornton,[a] Kristina M. Gicas,[b,c,d] Alexandra T. Vertinsky,[f] Manraj K. Heran,[f] Wayne Su,[b,c] G. William MacEwan,[c] Alasdair M. Barr,[b,g] William G. Honer,[b,c] and Allen E. Thornton[a,b,]**

[a]Department of Psychology, Simon Fraser University, Burnaby, BC, Canada
[b]British Columbia Mental Health and Substance Use Services Research Institute
[c]Department of Psychiatry, University of British Columbia, Vancouver, BC, Canada
[d]Department of Psychology, York University, Toronto, ON, Canada
[e]Department of Statistics and Actuarial Science, Simon Fraser University, Burnaby, BC, Canada
[f]Department of Radiology, University of British Columbia, Vancouver, BC, Canada
[g]Department of Anesthesiology, Pharmacology and Therapeutics, University of British Columbia, Vancouver, BC, Canada

eClinicalMedicine
2022;44: 101277

https://doi.org/10.1016/j.eclinm.2022.101277

Summary

Background Homeless and precarious housed persons are particularly prone to traumatic brain injuries (TBIs), but existent incidence rates are hampered by poor case acquisition. We rigorously documented TBIs in precariously housed persons transitioning in and out of homelessness.

Methods Between December 2016 and May 2018, 326 precariously housed participants enrolled in a longitudinal study in Vancouver, Canada were assessed monthly for TBI occurrences after education on sequelae. Over one participant-year, 2433 TBI screenings were acquired for 326 person-years and variables associated with odds of incident TBI were evaluated.

Findings One hundred participants acquired 175 TBIs, yielding an observed incidence proportion of 30·7% and event proportion of 53·7%. Of the injured, 61% reported one TBI and 39% reported multiple injuries. Acute intoxication was present for more than half of the TBI events assessed. Additionally, 9·7% of TBI events occurred in the context of a drug overdose. Common injury mechanisms were falls (45·1%), assaults (25·1%), and hitting one's head on an object (13·1%). In this community-based but non-randomly recruited sample, exploratory analyses identified factors associated with odds of an incident TBI over one year of follow-up, including: schizophrenia disorders (odds ratio (OR) = 0·43, 95% confidence interval (CI) 0·19, 0·94), role functioning (OR = 0·69, 95% CI 0·52, 0·91), opioid dependence (OR = 2·17, 95% CI 1·27, 3·72) and those reporting past TBIs (OR = 1·99, 95% CI 1·13, 3·52).

Interpretation Given the ubiquity of TBIs revealed in this precariously housed sample, we identify an underappreciated and urgent healthcare priority. Several factors modified the odds of incident TBI, which can facilitate investigations into targeted prevention efforts.

Funding Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, William and Ada Isabelle Steel Research Fund, Simon Fraser University Vice-President Research Undergraduate Student Research Award and Simon Fraser University Psychology Department Research Grant.

Keywords: Head injury; Concussion; Homelessness; Prevalence; Risk factors; Marginalization; Comorbidity

---

*Correspondence to: Allen E. Thornton, Human Neuropsychology Laboratory, Department of Psychology, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada.
E-mail address: aethornt@sfu.ca (A.E. Thornton).

Research in context

Evidence before this study

Our interests in the incidence rates of TBIs experienced in marginalized persons was spurred by concerns over prior case acquisition approaches, which was reinforced as we documented TBIs while conducting the "parent" 'Hotel Study', a broad investigation of the health of housing insecure persons. We subsequently published a *Lancet Public Heath* meta-analysis (Medline Embase, PsycINFO, CINAHL, Web of Science; search date Dec 14, 2018), which revealed a lifetime TBI prevalence in homeless and housing insecure samples exceeding 50% and identified TBI case acquisition limitations of past work, which we were positioned to address.

Added value of this study

Using standardized monthly TBI screenings conducted prospectively for one-year in precariously housed individuals, we more accurately documented TBIs. Rigorous methods, including missing data imputation, indicated that the annual incidence of TBI were unprecedently high. In the current study, we also identified several factors that were associated with odds of incident TBI, including greater odds with opioid use and past TBIs, and lesser odds associated with better role functioning and a diagnosis of schizophrenia disorders.

Implications of all the available evidence

This prospectively acquired data bolsters meta-analytic observations elucidating a community TBI endemic in at least some marginalized populations, while identifying factors apt to be relevant to injury risks and prevention. Considering that these community members often experience cognitive impairment, social and occupational challenges, and numerous morbidities (e.g., psychiatric and neurological), the high TBI incident rates observed serve as an impetus for studies into TBI-exacerbated neuropsychiatric decline, a potentially preventable source of disability in this and similar populations. To ensure that the full spectrum of TBI severity is captured, investigations will benefit from prospective TBI ascertainment methods optimized to the TBI experiences and reporting capacities of substance using, marginalized participants.

Introduction

Low-income tenants residing in substandard housing often as their only alternative to homelessness face high mortality and numerous mental and physical health challenges, including substance dependencies, psychiatric and neurological illnesses, and infectious diseases.[1-4] These persons also exhibit disproportionately high traumatic brain injury (TBI) incidence, with the most rigorously acquired annualized incidence rates approaching 20%.[5] Indeed, more than half of homeless and precariously housed persons report a TBI history, with one quarter of injuries characterized as moderate or severe as indicated by meta-analytically aggregated estimates.[6] These rates are several orders of magnitude higher than the <1% annualized incidence rates compiled from a comprehensive aggregation across multi-country studies.[7]

Yet, the extent of this problem remains elusive given numerous obstacles hampering accurate TBI ascertainment. Many studies of housing-insecure persons only incidentally document TBIs.[8] The use of well-validated ascertainment tools has been infrequent, and few studies comprehensively characterize mechanisms or risk factors.

Moreover, as in the broader TBI literature, ascertainment chiefly relies upon self-reports over timeframes where accurate recollection is often dubious. Report accuracy is likely further degraded in some populations of homeless and precariously housed persons because of compromised cognition[9] interfacing with limited participant knowledge and/or little recognition of TBI-associated symptoms.[10]

Increased data granularity and fidelity will improve TBI rate estimates and identify measures for prospective studies of risk factors. Accordingly, in precariously housed persons, our aims were to estimate TBI incidence and explore risks using a design that included the education of participants on TBI sequelae and a validated screening tool deployed repeatedly and proximate to injury. We explored putative risk factors specifically (e.g., opioid dependence) as opposed to broadly (e.g., substance dependence). Such work is vital given the potential of particularly deleterious impacts of TBIs, and their accumulation, in persons suffering from poor physical and mental health.[11,12]

Methods

Participants

As part of a longitudinal study, 524 individuals were recruited in Vancouver, Canada between November 2008 and May 2018 from four single room occupancy (SRO) hotels located in a low-income neighbourhood, the community court, and the emergency department of the catchment area hospital (see the "Hotel Study"[1] for baseline characteristics). Briefly, persons were eligible if they lived in the neighbourhood catchment area, were able to communicate in English, and had the capacity to and provided written informed consent. Between December 2016 and May 2018, a total of 326 of these individuals completed monthly TBI screening assessments (Figure 1). Participants received small honoraria after each screening. Ethics approval was obtained from the University of British Columbia – Providence Health Care Research Ethics Board (H16-01310) and the Simon Fraser University Office of Research Ethics (2016s0586).

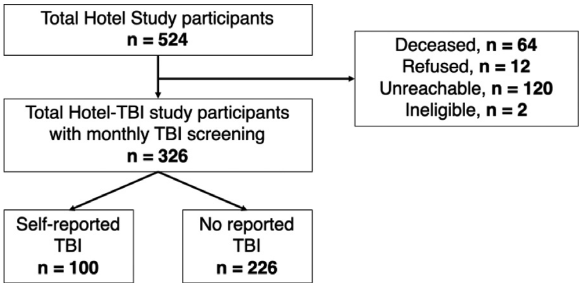


Figure 1. Flow diagram of participant inclusion.

Procedures

Traumatic brain injury screening was completed by trained research assistants supervised by a Neuropsychiatrist (WJP) and Psychologist (AET). At recruitment for the TBI sub-study, participants were provided with a pamphlet outlining common TBI causes and symptoms, as well as contact information for a nearby emergency room and several area clinics (available by request). Participants were encouraged to first seek medical service in the event of a head injury. Apart from two TBI events that were reported between scheduled monthly screenings, participants reported all events during monthly screenings that occurred over a one person-year period tailored to each person's enrolment date. A total of 2433 unique monthly screenings were completed across 326 person-years. On average, participants completed 7·73 screens (*SD* = 3·63; *median* = 8·00), with a range of 1 to 14 screens. Across the possible 326 person-years, data was present across 202·75 person-years (37·8% missing monthly data).

Prospective TBI occurrence was ascertained during monthly screening using the Ohio State University TBI Identification Method Interview Form,[13] which is a TBI Common Data Elements measure.[14] A supplemental questionnaire was used to augment injury details (Supplement A). To establish TBI occurrence, two definitions were employed. A standard, but more liberal definition,[15] operationalized TBI as a trauma to the head or neck, with known cause, resulting in one or more of loss of consciousness (LOC), post-traumatic amnesia (PTA), and/or being dazed and/or confused. A more conservative definition required a reported period of LOC, at minimum, to be considered a TBI. When participants affirmed TBI but lacked autobiographical event recollection sufficient to make a definitive TBI diagnosis, criteria were met if a witness had conveyed qualifying injury information that the participant disclosed, or if the participant presented with physical signs of head trauma. When TBI events were reported in duplicate, only one TBI occurrence was included in analyses. Lifetime TBI count was assessed using the Brain Injury Screening Questionnaire.[16] Finally, a post-study consensus review of "suspect" TBI events was conducted that identified events in which sensorial disruption reportedly occurred prior to head impact. These "suspect" events were often reported as entailing "passing out" with a subsequent head impact.

The mechanism of TBI was investigated, including whether the event occurred in the context of overdose or acute intoxication. Given the ubiquity of substance dependence, intoxication at the time of injury was defined using a questionnaire item probing self-reported intoxication by drugs or alcohol at the time of injury that was *beyond typical use*. Further, TBIs were considered to have occurred during non-alcohol induced overdose if there was, inclusively: (a) an observer report or observable sign of head trauma, (b) self-reported drug use at the time of injury, and (c) self-report of naloxone administration.

Several procedures were conducted that characterized the sample clinically and provided the basis for the evaluation of measures putatively associated with odds of incident TBI (Supplement B). Substance dependencies and psychiatric illnesses were diagnosed by interview with a psychiatrist using the Diagnostic and Statistical Manual of Mental Disorders[17] in consensus with the Best Estimate Clinical Evaluation and Diagnosis 2[18] and the most proximally conducted Mini International Neuropsychiatric Interview.[19] The Maudsley Addiction Profile physical and mental symptom scores were used to estimate health.[20] In structured interview, details on physical symptoms and illnesses were collected, which included neurological illnesses (e.g., stroke, epilepsy, and seizure history) and remote TBI histories (i.e., "*serious* head/face injury" with LOC).

Neurocognitive and functional capacity information, collected prior to monthly TBI screening, generated additional measures considered for association with TBI. Premorbid intelligence was estimated using the reading score, in combination with demographics, as implemented on the Wechsler Test of Adult Reading.[21] Two additional variables were created (see Supplement B). First, composite cognition was calculated from the Hopkins Verbal Learning Test – Revised[22] (immediate recall), the Stroop Color and Word Test[23] (color-word trial), and the Rapid Visual Information Processing Test[24] (signal detection, A′). Additionally, role functioning was captured by a sample-standardized composite derived from raw scores on the Role Functioning Scale[25] and the Social and Occupational Functioning Assessment Scale.[17] Lower scores on the role functioning composite reflect poorer working productivity, diminished independent living and self-care skills, and/or lesser engagement in immediate or extended social relationships.

Statistical Analysis

The *observed TBI rates* can be appreciated as a lower boundary, since observed rates are attenuated by missing data. In contrast, *estimated rates* achieved through imputation, mitigate biases. Following the framework outlined by Richter and colleagues[26] for handling missing data in observational TBI research, longitudinal missing data patterns were examined. Generalized linear modeling examined whether relevant demographic, time variant, psychiatric, and TBI-related variables were associated with whether data was present versus missing across all possible time points, with each participant's scores as a cluster (see Supplement C). The missingness mechanism was determined.[27] Multiple imputation by chained equations[28] was performed to impute missing data. Of note, comparable longitudinal analyses were performed to determine if relevant variables were associated with whether participants came in to report a TBI or not; no variables were predictive.

In exploratory analyses, variables that were investigated as modifiers of odds for TBI were harvested from the closest available data collection point preceding each participant's first prospective TBI screening. Regressions were conducted to examine factors modifying the odds of TBI occurrence. For all analyses, assumptions were met and the number of TBI events per number of variables in the model was not found to exceed values thought to cause bias and/or precision errors.[29] All categorical variables were coded in reference to their absence (e.g., participants without schizophrenia disorders). Continuous variables were coded as changes in the odds of sustaining TBI with every unit change on the continuous variable.

To evaluate odds related to TBI occurrence, a series of hierarchical binomial logistic regressions were conducted. These exploratory models were constructed to provide coefficients adjusted for demographics and similar taxonomy risks (i.e., substance dependence, psychiatric disorders, neurological indicators, and psychological and daily functioning; see Figure 4, Blocks 2a-d). Specifically, age, sex, and education were entered on Block 1 and variables exclusive to each taxonomy were entered on Blocks 2a-d. The reported odds ratios are adjusted for demographics and for the factors exclusive to the taxonomy.

Generalized linear modeling and multiple imputation analyses were conducted using R version 3·6·3. All other statistical analyses were conducted using Statistical Package for the Social Sciences version 24·0. TBI screening data was double checked by select authors. Data was then entered into databases and checked and cleaned by research assistants and select authors. The study is reported in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Guidelines.[30]

Role of Funding Sources

Funders of this study played no part in research design, data collection/analysis, interpretation, or in writing the manuscript. All authors had access to the data and were responsible for the submission.

Results

Demographic and clinical characteristics of the sample are given in Table 1. Test-retest reliability was conducted on self-reported injury details from an available subsample of precariously housed persons enrolled in the study who repeated TBI screening (n = 42) for the same event at a later visit (*mean* = 7·88 days, *SD* = 4·78, range 4-19 days). Reliability estimates were calculated based on a single rating, absolute-agreement, two-way mixed effects model. Using Cicchetti guidelines,[31] reliabilities were excellent for self-report of TBI mechanism (intraclass correlation coefficient (*ICC)* = 0·950), as well as for LOC occurrence and its duration (*ICCs* = 0·908 and 0·973, respectively). Reliability was fair for the occurrence of PTA or being dazed and/or confused (*ICC* = 0·453), but poor for its duration (*ICC* = 0·126).

To establish the most comprehensive and accurate TBI rates, we examined the TBIs across the sample for the observation period using the observed and estimated (imputed) datasets. For analyses, the standard definition was deemed primary. For completeness, we also report *observed* TBIs using the conservative definition (requiring LOC; Table 2).

Over the possible 326 person-years, 175 TBI events were reported in 100 participants and 226 participants reported no events. Of those who acquired at least one event, 61% of participants reported only one TBI, and 39% reported two or more injuries (range 0 to 6; see Figure 2). Table 2 reveals an *observed* (unimputed) annual incidence proportion of 30·7% (100 of 326 individuals experienced TBI) and an observed event proportion of 53·7% (175 events in 326 individuals). The observed incidence rate (100 individuals with TBI over 202·75 person-years) was 0·49 persons per year and the observed event rate (175 events over 202·75 person-years) was 0·86 events per year. Fail-safe estimates of observed TBIs were established by removing the 27 "suspect" events (reported by 13 participants) that involved sensorial disruption that occurred prior to head impact (e.g., falling during an overdose). With this approach, the fail-safe observed incidence proportion (87 individuals with TBI out of 326 total individuals) was 26·7% versus 30·7% and the event proportion (148 TBI events out of 326 total individuals) was 45·4% versus 53·7%.

Finally, imputation that mitigates missing data biases under the missing at random (MAR) assumption yielded *estimates* that were 65 to 70% higher than that of the *observed* rates. Table 2 provides these *estimates*, with a TBI incidence proportion of 50·7% and an event proportion of 91·1%.

To appreciate the TBI events, we characterized their mechanisms and symptom features. One hundred forty-two of 175 events (81·1%) reported no LOC or a LOC of 30 minutes or less, 32 (18·3%) reported LOC longer than 30 minutes, and 1 (0·6%) was unknown. Table 3 reveals that the most common mechanisms

Clinical Characteristic	Total N	N	%
		M (SD)	
Demographics			
Age (years)	326	40·5 (11·3)	
Education (years)	326	10·5 (2·3)	
Monthly Income (Canadian dollars)	322	850·3 (415·3)	
Sex			
Males	326	239	73·3
Females	326	87	26·7
Ethnicity			
Caucasian	324	180	55·6
Indigenous	324	91	28·1
Other	324	53	16·4
Alcohol and Drug Dependence			
Alcohol	297	59	19·9
Stimulant	297	232	78·1
Opioid	297	129	43·4
Cannabis	297	113	38·0
Other	294	27	9·2
Psychiatric Disorders			
Depression	297	42	12·9
Bipolar spectrum disorder	296	32	10·8
Schizophrenia spectrum disorder	297	55	18·5
Substance induced psychotic disorder	297	47	15·8
Other	295	170	57·6
Neurological Disorders			
Lifetime traumatic brain injury count	326	Median = 3·00 (IQR = 4·0)	
Lifetime traumatic brain injury history	326	108	33·1
Pre-enrollment MRI-defined traumatic brain injury	283	15	5·3
History of seizures/epilepsy	323	50	15·5
History of stroke	321	13	4·0

***Table 1*: Sample Demographic and Clinical Characteristics.**

Note: Stimulant = cocaine and/or methamphetamine. Opioid = heroin and/or other opioid. Pre-enrollment Magnetic resonance imaging (MRI)-defined TBIs were determined from scans that were conducted prior to enrollment in monthly TBI screening.

TBI Definition	Incidence Proportion (per 100,000 population)	Event Proportion (per 100,000 population)	Incidence Rate (per 100,000 person-years)	Event Rate (per 100,000 person-years)
Standard				
Observed	30,674·85	53,680·98	49,321·82	86,313·19
Estimated	50,674·85	91,104·29	50,674·85	91,104·29
LOC required				
Observed	18,711·66	27,914·11	30,086·31	44,882·86

***Table 2*: Rates of Traumatic Brain Injury.**

were falls, assaults, and hitting one's head on an object. Seventeen events (9·7%) occurred in the context of a drug overdose. Acute intoxication was assessed for 79 TBI events (45·1% of all events) as this evaluation was initiated after the study was underway. Of these 79 events, 48 (60·8%) were acquired when the participant was intoxicated.

Females showed little difference compared to males in their odds for incident TBI (odds ratio (OR) = 1·111; 95% confidence interval (CI) ·778, 1·586; 99% CI ·695, 1·773). As for mechanisms, females were at higher odds than males for sustaining a TBI from falling (OR = 2·28; 95% CI 1·128, 4·607; 99% CI ·904 – 5·746), while males had higher odds than females for

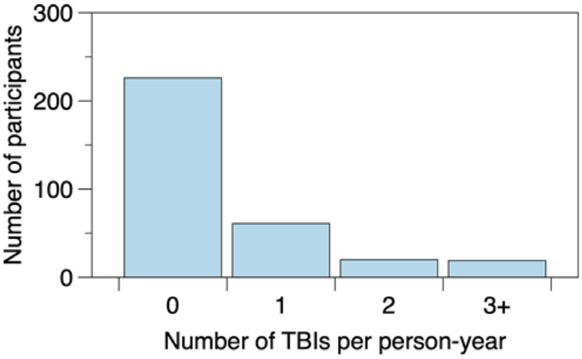


Figure 2. Frequency of Traumatic Brain Injury Count.

sustaining a TBI from assault (OR = 3·18; 95% CI 1·167, 8·703; 99% CI ·851, 11·934; see Figure 3).

As indicted in Figure 4, exploratory binomial logistic regression revealed associations with emergent TBI occurrence (standard definition) as reported by participants during the screening year. These odds ratios and their 95% CIs reveal that as education increased, the odds for TBI lessened (see Figure 4, Block 1). In terms of substance dependencies, participants with opioid dependence were at higher odds for incident TBI than those without (Block 2a), while other dependencies appeared less crucial. Persons in this sample with schizophrenia spectrum disorder, who often function more poorly, had lower odds for TBI occurrence compared to those without this disorder (see Block 2b).

Mechanism	Number of TBI Events	Percentage of Total TBI Events	Number in Context of Drug Overdose	Number in Context of Acute Intoxication
Fall	79	45·1	15	32
Assault	44	25·1	0	8
Hit head on Object	23	13·1	2	4
Hit by Object	10	5·7	0	2
Pedestrian Accident	9	5·1	0	1
Biking/Sports Related	6	3·4	0	1
Motor Vehicle Accident	1	0·6	0	0
Unknown	3	1·7	0	0
Other	0	0	0	0
Total	**175**	**100**	**17 (of 175; 9·7%)**	**48 (of 79*; 60·6%)**

***Table 3*: Mechanisms of Traumatic Brain Injury.**
Note: *Self-reports of acute intoxication were obtained for 79 of the total 175 injuries.

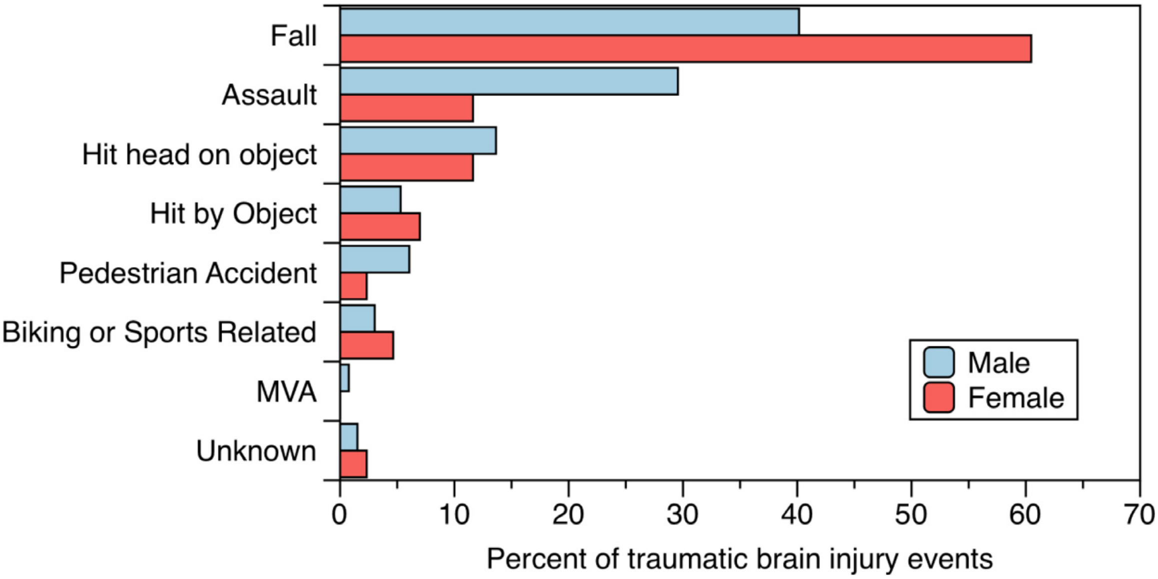


Figure 3. Mechanisms of Traumatic Brain Injury by Sex.

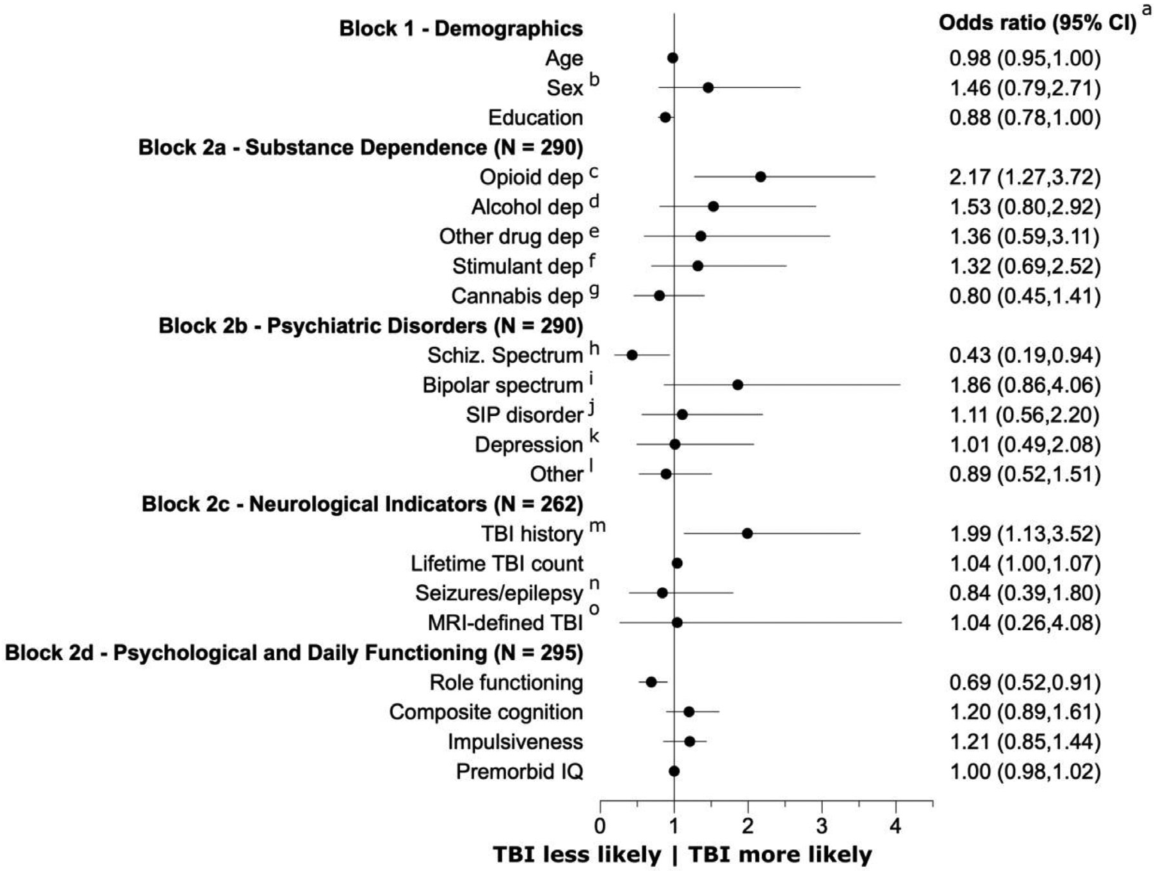


Figure 4. Binomial Logistic Regressions of Variables Tested for Association with Traumatic Brain Injury Occurrence with 95% confidence intervals.
Note: CI = confidence interval. [a] Adjusted for age, sex, and education. [b] N female = 87. Dep = dependence. [c] N = 129. [d] N = 59. [e] N = 27. [f] N = 232. [g] N = 113. Schiz = schizophrenia. [h] N = 55. [i] N = 32. SIP = substance induced psychosis. [j] N = 47. [k] N = 42. [l] N = 170. TBI = traumatic brain injury. [m] N = 108. [n] N = 50. MRI = magnetic resonance imaging. [o] N = 15. IQ = intelligence.

Select neurological indicators were also notable. Participants with prior “lifetime” TBI histories showed higher odds for incident TBI, and the odds for TBI increased with each “lifetime” TBI reported (i.e., TBI count; Block 2c). Finally, as composite role functioning increased, the odds for TBI lessened (Block 2d). See Supplement D for number of individuals with TBI occurrence by each variable tested for association. Note that after applying 99% CIs to the data, interval bounds for select OR that are highlighted above encompass one. Specifically, these indicators include the lower odds for TBI associated with more education and the diagnosis of schizophrenia disorders, and the higher odds associated with TBI history and lifetime TBI count (see Supplement E).

Discussion

The current study, using rigorous ascertainment procedures designed to capture TBI incidence and risks comprehensively, revealed that TBI rates in these precariously housed persons were higher than those of past reports. With a standard definition of TBI, the 31% *observed* incidence proportion was 1·6 to 1·8 times higher than that reported in other homeless and insecurely housed samples[5] and several orders of magnitude higher than a report derived from meta-analytically compiled population-based studies.[7] Importantly, studies often utilized administrative datasets and registries for TBI acquisition, likely missing mild TBIs cases. With bias-corrected imputation, our data indicates that ∼51% of marginalized persons in the present sample experience at least one TBI annually (i.e., *estimated* incidence proportion). Given the screening duration, the *estimated* event rate indicated that that ∼0·91 events occur for every person-year of observation.

Methodological improvements including proximal and repeated screening for brain injury likely contribute to these considerably higher self-reported TBI rates than have been previously reported in homeless and housing-insecure samples. Existent research often screens for head injury only annually without standardized participant education. Such approaches likely miss mild and temporally distal injuries, thereby underestimating rates. The remarkably high TBI rates reported here reveal an underappreciated community endemic, warranting prioritization by health and research stakeholders through prevention efforts.

The injury mechanisms revealed, and the odds ratios for incident TBI, are germane to intervention approaches going forward. In terms of mechanisms, falls and assaults were frequently observed, with some evidence of sex differences, i.e., more fall-related TBIs in females and more assault-related TBIs in males. Opioid dependence increased odds for TBI and schizophrenia disorders lessened the odds. Two particularly concerning patterns were also apparent in exploratory analyses. First, remote *lifetime* TBI histories increased the odds for new occurrence and more *lifetime* TBIs incremented the odds further. Second, poorer role functioning conveyed higher odds for TBI, potentially indicating a bidirectional pattern. Over time these two patterns suggest a route for progressively acquired disability that emerges as functioning declines, presumably with the accumulated TBI exposures. Comprehensive educational and outreach approaches could be developed to prevent possible debilitating effects arising with the accumulation of TBIs. Managing health conditions, recognizing one's life stage, and providing choice and opportunity can improve an individual's role functioning.[32] Such interventions warrant further investigation.

There are several limitations that should be considered. In the acquisition of head injuries, we relied on self-report, a method susceptible to the response biases, limited insight, and memory errors. Although these inherent problems plague all self-reports of TBI, their impact here was likely mitigated by TBI education and repeated screening at short intervals. Of note is that a study subsample reliably reported critical injury details ensuring that participants were consistent in several aspects of event reporting. Second, participants received small monetary honoraria after each screening and a subset of participants received additional compensation after undergoing a neurocognitive evaluation (not reported here). This raises concern of false reports of TBI to acquire compensation. Yet, we did not detect any relevant variables associated with TBI reporting, suggesting that compensation seeking was not at play. Further, TBIs were often acquired in the context of acute intoxication *beyond typical use* or overdoses, potentially conflating substance-related effects with TBI-defining features. Consequently, false positive errors and greater severity designations because of contributory substance effects might occur. When TBIs were reported with insufficient self-reported recollection to provide a TBI diagnoses, we mitigated false positive ascertainment errors by requiring witness verification and/or observable signs of trauma. Nonetheless, the veracity of TBI reports is an intractable problem for this and similar community-based research, given that reports might often be conflated with brain dysfunction arising from intoxication/substance use which could interact with TBI-induced brain dysfunction. Future investigations that critically operationalize criteria for TBI diagnosis and characterization in persons with severe substance use disorders would be beneficial. Finally, like other reports directly investigating TBI incidence in homeless or marginally housed participants, sampling was non-random. Consequently, generalization of the results should be cautiously considered. The incidence statistics reported (i.e., observed and imputed) are estimates of the true rate of TBI in the present community-based sample, that shares demographic features with other (non-random) samples from the same neighbourhood, and in other Canadian cities.[2] Our findings may be less applicable to other populations comprised of unsheltered or emergency sheltered homeless persons. As with all non-random studies, probabilistic analyses of variables creating risk cannot be carried out.

Our understanding of TBIs in precariously housed and homeless persons is limited, especially given the apparent prior underestimates of its pervasiveness. The current observations suggest that precariously housed persons very frequently experience TBIs. Considering that this population also experiences high rates of existent cognitive impairment, social and occupational dysfunction, and often a host of concerning multimorbidities (e.g., psychiatric, neurological), the remarkable TBI rates should serve as an impetus for detailed investigation into their neurocognitive and functional impacts. This is particularly true for the typical mild injuries, given their potential for cumulative functional consequences.

Declaration of interests

WJP: Grant funding from the Canadian Institutes of Health Research, Brain Injury Canada and ACRM Task Force

LX: Grant funding from Simon Fraser University Undergraduate Student Research Award.

XJH: Grant funding from the Canadian Natural Science and Engineering Discovery Grant Program and Simon Fraser University Undergraduate Student Research Award.

WGH: Grant funding from the Canadian Institutes of Health Research

AET: Grant funding from the Canadian Institutes of Health Research; Simon Fraser University William and Ada Isabelle Steel Research Fund and Simon Fraser University Psychology Department Research Grant.

All other authors report no conflicts.

Contributors

All authors edited final versions of the manuscript with access to all the data. All authors approved that the manuscript be submitted for publication.

TAO contributed to conceptualisation, data curation, formal analysis, investigation, methodology, project administration, validation, visualisation, data verification, writing the original draft and editing.

WJP contributed to conceptualisation, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, visualisation, and review and editing.

EML contributed to data curation, investigation, methodology, and project administration.

JLS contributed to data curation, investigation, methodology, visualization, and review and editing.

JA contributed to data curation, investigation, methodology, and project administration.

CSS contributed to data curation, investigation, and methodology.

SJF contributed to project administration, data curation, investigation, methodology, and review and editing.

TB contributed to project administration, supervision, data curation, investigation, and methodology.

LX contributed to formal analysis and methodology.

XJH contributed to formal analysis, methodology, supervision and review and editing.

DJL contributed to data curation, investigation, methodology, project administration and review and editing.

MLW contributed to data curation, investigation, and methodology.

WLT contributed to investigation, methodology, review and editing, and supervision.

KMG contributed to investigation, methodology, and review and editing.

ATV contributed to data curation and investigation.

MKH contributed to data curation and investigation.

WS contributed to data curation and investigation.

GWM contributed to conceptualisation, data curation, funding acquisition, investigation, methodology, project administration

AMB contributed to conceptualisation, funding acquisition, investigation, and methodology.

WGH contributed to conceptualisation, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, visualisation, and review and editing.

AET contributed to conceptualisation, data curation, formal analysis, investigation, methodology, project administration, resources, supervision, validation, visualisation, data verification, writing the original draft and editing.

Data Sharing Statement

Our individual level participant data collected from a specific community includes identifiers of age, gender, income, use of non-prescribed drugs and symptom severity scores, all of which are needed for analyses. We cannot provide this data due to potential privacy infringement and related ethical and legal obligations to participants as restricted by the University of British Columbia Clinical Research Ethics Board and Simon Fraser University's Research Ethics Board. For all requests regarding data, please contact the Clinical Research Ethics Board, University of British Columbia (ethics.research.ubc.ca) and the responsible authors at aethornt@sfu.ca and will.panenka@ubc.ca.

Acknowledgements

We would like to acknowledge the participants who volunteer for this study and the research assistants who contributed to the project.

Funding

Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, William and Ada Isabelle Steel Research Fund, Simon Fraser University Vice-President Research Undergraduate Student Research Award and Simon Fraser University's Psychology Department Research Grant.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2022.101277.

References

1 Vila-Rodriguez F, Panenka WJ, Lang DJ, et al. The Hotel Study: Multimorbidity in a community sample living in marginal housing. *Am J Psychiatry*. 2013;170(12):1413–1422. https://doi.org/10.1176/appi.ajp.2013.12111439.

2 Hwang SW, Aubry T, Palepu A, et al. The health and housing in transition study: A longitudinal study of the health of homeless and vulnerably housed adults in three Canadian cities. *Int J Public Health*. 2011;56(6):609–623. https://doi.org/10.1007/s00038-011-0283-3.

3 Jones AA, Vila-Rodriguez F, Leonova O, et al. Mortality from treatable illnesses in marginally housed adults: A prospective cohort study. *BMJ Open*. 2015;5(8):1–8. https://doi.org/10.1136/bmjopen-2015-008876.

4 Fazel S, Geddes JR, Kushel M. The health of homeless people in high-income countries: Descriptive epidemiology, health consequences, and clinical and policy recommendations. *Lancet*. 2014;384(9953):1529–1540. https://doi.org/10.1016/S0140-6736(14)61132-6.

5 Nikoo M, Gadermann A, To MJ, Krausz M, Hwang SW, Palepu A. Incidence and associated risk factors of traumatic brain injury in a cohort of homeless and vulnerably housed adults in 3 Canadian cities. *J Head Trauma Rehabil*. 2017;32(4):E19–E26. https://doi.org/10.1097/HTR.0000000000000262.

6 Stubbs JL, Thornton AE, Sevick JM, et al. Traumatic brain injury in homeless and marginally housed individuals: A systematic review and meta-analysis. *Lancet Public Heal*. 2020;5(1):e19–e32. https://doi.org/10.1016/S2468-2667(19)30188-4.

7 Nguyen R, Fiest KM, McChesney J, et al. The international incidence of traumatic brain injury: A systematic review and meta-analysis. *Can J Neurol Sci*. 2016;43(6):774–785. https://doi.org/10.1017/cjn.2016.290.

8 Topolovec-Vranic J, Ennis N, Colantonio A, et al. Traumatic brain injury among people who are homeless: A systematic review. *BMC Public Health*. 2012;12(1). https://doi.org/10.1186/1471-2458-12-1059.

9 Gicas KM, Vila-Rodriguez F, Paquet K, et al. Neurocognitive profiles of marginally housed persons with comorbid substance dependence, viral infection, and psychiatric illness. *J Clin Exp Neuropsychol*. 2014;36(10):1009–1022. https://doi.org/10.1080/13803395.2014.963519.

10 Willer B, Johnson WE, Rempel RG, Linn R. A note concerning misconceptions of the general public about brain injury. *Arch Clin Neuropsychol*. 1993;8(5):461–465. https://doi.org/10.1016/10887-6177(93)90009-P.

11 Schmitt T, Thornton AE, Rawtaer I, et al. Traumatic brain injury in a community-based cohort of homeless and vulnerably housed individuals. *J Neurotrauma*. 2017;34(23):3301–3310. https://doi.org/10.1089/neu.2017.5076.

12 Gicas KM, Jones AA, Thornton AE, et al. Cognitive decline and mortality in a community-based sample of homeless and precariously housed adults: 9-year prospective study. *BJPsych Open*. 2020;6(2):1–8. https://doi.org/10.1192/bjo.2020.3.

13 Corrigan JD, Bogner J. Initial reliability and validity of the *Ohio State University TBI Identification Method*. *J Head Trauma Rehabil*. 2007;22(6):318–329. https://doi.org/10.1097/01.HTR.0000300227.67748.77.

14 Hicks R, Giacino J, Harrison-Felix C, Manley G, Valadka A, Wilde EA. Progress in developing common data elements for traumatic brain injury research: Version Two-the end of the beginning. *J Neurotrauma*. 2013;30(22):1852–1861. https://doi.org/10.1089/neu.2013.2938.

15 Carroll LJ, Cassidy JD, Holm L, Kraus J, Coronado VG. Methodological issues and research recommendations for mild traumatic brain injury: The WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *J Rehabil Med Suppl*. 2004:(43):113–125. https://doi.org/10.1080/16501960410023877.

16 Dams-O'Connor K, Cantor JB, Brown M, Dijkers MP, Spielman LA, Gordon WA. Screening for traumatic brain injury: Findings and public health implications. *J Head Trauma Rehabil*. 2014;29(6):479–489. https://doi.org/10.1097/HTR.0000000000000099.

17 American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (4th Ed.)*. 4th ed. Washington, DC: American Psychiatric Association; 2000. https://doi.org/10.1176/ajp.152.8.1228.

18 Endicott J. *Best Estimate Clinical Evaluation and Diagnosis Form (BECED)*. New York: Department of Research Assessment and Training, New York State Psychiatric Institute; 1988.

19 Sheehan D V, Lecrubier Y, Sheehan KH, et al. The *Mini-International Neuropsychiatric Interview* (MINI): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *J Clin Psychiatry*. 1998;59(Suppl 20):22–33.

20 Marsden J, Gossop M, Stewart D, et al. The *Maudsley Addiction Profile* (MAP): A brief instrument for assessing treatment outcome. *Addiction*. 1998;93(12):1857–1867. https://doi.org/10.1046/j.1360-0443.1998.931218571.x.

21 Venegas J, Clark E. In: Kreutzer JS, DeLuca J, Caplan B, eds. *Encyclopedia of Clinical Neuropsychology*. New York, NY: Springer New York; 2011. https://doi.org/10.1007/978-0-387-79948-3.

22 Belkonen S. Hopkins Verbal Learning Test. In: Kreutzer JS, DeLuca J, Caplan B, eds. *Encyclopedia of Clinical Neuropsychology*. New York, NY: Springer New York; 2011:1264–1265. https://doi.org/10.1007/978-0-387-79948-3_1127.

23 Rozenblatt S. Stroop Color Word Test (adult). In: Kreutzer JS, DeLuca J, Caplan B, eds. *Encyclopedia of Clinical Neuropsychology*. New York, NY: Springer New York; 2011:2404–2405. https://doi.org/10.1007/978-0-387-79948-3_660.

24 Fray PJ, Robbins TW, Sahakian B. Neuropsychiatric applications of *CANTAB*. *Int J Geriatr Psychiatry*. 1996;11(4):329–336. https://doi.org/10.1002/(SICI)1099-1166(199604)11:4<329::AID-GPS453>3.0.CO;2-6.

25 Goodman SH, Sewell DR, Cooley EL, Leavitt N. Assessing levels of adaptive functioning: The *Role Functioning Scale*. *Community Ment Health J*. 1993;29(2):119–131. https://doi.org/10.1007/BF00756338.

26 Richter S, Stevenson S, Newman T, et al. Handling of missing outcome data in traumatic brain injury research: A systematic review. *J Neurotrauma*. 2019;36(19):2743–2752. https://doi.org/10.1089/neu.2018.6216.

27 Rubin DB. Inference and missing data. *Biometrika*. 1976;63(3):581–592. https://doi.org/10.1093/biomet/63.3.581.

28 Twisk J, dr Boer M, de Vente W, Heymans M. Multiple imputation of missing values was not necessary before performing a longitudinal mixed-model analysis. *Journal of Clinical Epidemiology*. 2013;66:1022–1028. https://doi.org/10.1016/j.jclinepi.2013.03.017.

29 Peduzzi P, Concato J, Feinstein AR, Halford TR. A simulation study of the number of events per variable recommended in multivariable regression analyses. *Control Clin Trials*. 1996;49(12):1373–1379. https://doi.org/10.1016/s0895-4356(96)00236-3.

30 Benchimol EI, Smeeth L, Guttmann A, et al. RECORD Working Committee. The reporting of Studies Conducted using Observational Routinely-Collected health Data (RECORD) statement. *PLoS Med*. 2015;12:(10):e1001885. https://doi.org/10.1371/journal.pmed.1001885.

31 Cicchetti D V. Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment insturments in psychology. *Psychol Assess*. 1993;6(4):284–290. https://doi.org/10.1037/1040-3590.6.4.284.

32 Anatchkova MD, Bjorner JB. Health and role functioning: the use of focus groups in the development of an item bank. *Qual Life Res*. 2010;19(2010):111–123. https://doi.org/10.1007/s11136-009-9570-3.

Traumatic Brain Injury and Treatment of Behavioral Health Conditions

John D. Corrigan, Ph.D.

Traumatic brain injury (TBI) is a common neurological condition that results from an external force altering normal brain function, whether temporarily or permanently. A concussion is one type of TBI. TBIs vary greatly in severity, which concomitantly creates tremendous variability in their manifestation. The fingerprint of TBI is damage to the frontal areas of the brain, which, with sufficient magnitude, results in impairment of a person's ability to regulate cognition, emotion, and behavior. These consequences of TBI make recognition in the context of treating behavioral health conditions of utmost importance. TBI not only causes behavioral health problems but also produces associated deficits that can undermine the effectiveness of treatment for a behavioral health condition. This overview delineates key characteristics of TBI and describes its association with behavioral health conditions. Mechanisms underlying the relationship between TBI and behavioral health are presented, and a series of recommendations for professionals are proposed. This article is intended to raise awareness about TBI and simultaneously introduce key concepts for accommodating the effects of TBI in behavioral health care.

Psychiatric Services 2021; 72:1057–1064; doi: 10.1176/appi.ps.201900561

In 2013, the most recent year for which U.S. data are available, traumatic brain injury (TBI) resulted in 2.8 million emergency department visits, hospitalizations, or deaths (1), accounting for almost 2% of similar medical encounters in the United States. Among these encounters, approximately 89.3% of patients (N=2.5 million) were treated and released from emergency departments, another 10% (N=282,000) were hospitalized and discharged alive, and approximately 2% (N=56,000) died. The number of TBI-related emergency room visits had increased by more than 50% since 2007. Heightened public awareness of TBI due to publicity about sports-related concussions and TBIs incurred in combat in Iraq and Afghanistan contributed to the increase in medically treated TBIs. However, the greatest increase was in the rate of fall-related TBIs among older adults. The annual cost to society of neurological conditions was almost $8 billion, of which TBIs accounted for more than 10% (2). The prevalence of disability caused by TBIs is 1.1% among U.S. adults, but when all sources of long-term consequences are considered, the prevalence rate is substantially higher (3, 4).

Although public awareness of TBI has shifted dramatically since it was dubbed "a silent epidemic" in 1980, appreciation of its effects has not garnered the attention of professionals outside of rehabilitation. Particularly among behavioral health specialists, a gap remains in knowledge about TBI, the understanding of its implications for behavioral health conditions, and active consideration of treatment implications. This overview is intended as an initial attempt to summarize the key elements of the disorder and to elucidate the multiple points of convergence with behavioral health concerns. These descriptions are followed by a very brief presentation of possible mechanisms that underlie the relationship between TBI and behavioral health concerns. The final sections of this overview include recommendations based on clinical experience about how behavioral health programs and professionals can better meet the needs of their clients who also have had a TBI.

HIGHLIGHTS

- Traumatic brain injury (TBI) is prevalent among persons with behavioral health problems.
- The fingerprint of TBI is damage to the frontal areas of the brain, regardless of where the blow to the head occurs.
- Damage to frontal areas cause cognitive and executive functioning deficits that both increase the likelihood of behavioral health problems and make treatment more difficult.
- The behavioral health workforce needs to secure the knowledge and skills to identify patients' problematic histories of TBI and accommodate the resulting neurological effects in treatment.

TBI is defined as follows:

> An alteration in brain function, or other evidence of brain pathology, caused by an external force. External forces include the head being struck by an object; the head striking an object; the head accelerating or decelerating without direct external trauma (as occurs in shaken baby syndrome); a foreign body penetrating the brain; or energy generated from events such as a blast or explosion. (5)

WHAT IS TBI?

A TBI is "an alteration in brain function, or other evidence of brain pathology, caused by an external force" (5). The requirement for TBI to be due to an external force clearly separates it from other brain injuries that occur in the prenatal period (e.g., cerebral palsy) or those with onset after birth, such as injuries due to cerebral vascular accidents (e.g., stroke), anoxia or hypoxia (e.g., when the heart stops beating), or electrical shock. Furthermore, the requirement that TBI include both an external force and alteration in brain function distinguishes it from injuries to the head alone, such as abrasions or contusions to the face or scalp. The usefulness of distinguishing TBI from other types of brain injury will become clearer when mechanisms for the association with behavioral health conditions are described below.

The effects of TBI vary greatly, ranging from a brief, temporary disruption in thinking, which is experienced as being dazed or confused, to being in a coma, during which the brain is not able to respond reflexively to pain or other strong stimuli. This range of effects parallels definitions of the severity of the injury. Mild TBI includes being dazed or confused or losing consciousness (i.e., knocked out) for up to 30 minutes (6). Moderate severity ranges from 30 minutes to 24 hours of lost consciousness, whereas severe TBI involves being unconscious for more than 24 hours and generally involves being in a coma (5).

Although the severity of the initial injury is a major determinant of the eventual residual consequences, other characteristics of the injury can influence effects, even when the injury is mild. For instance, much attention has been given to repeated mild TBI as it occurs in contact sports or during combat. Although more questions remain than have been answered, the actual number of injuries, and even the forces exerted on the brain from multiple mild TBIs, may not determine residual consequences as much as the time between injuries does (7, 8). Incurring a second TBI, even if mild, while the brain is still accommodating the first injury may create vulnerabilities that underlie long-term effects (7).

Another circumstance in which mild TBIs may carry greater consequence is childhood injury. Several studies have observed later consequences from TBIs in very early life (9, 10), whereas other studies have suggested that onset during adolescence has the greatest chance of creating later consequences (11, 12). It is notable that childhood injuries may be particularly responsible for adult behavioral health problems, an observation that has additional support in animal models (13, 14).

TBI AND BEHAVIORAL HEALTH PROBLEMS

There have been multiple reviews of the behavioral health consequences that develop after TBI, including a recent comprehensive investigation by Ponsford and colleagues (15). Retrospective, cross-sectional, and prospective studies of TBI cohorts were reviewed for major classes of behavioral health conditions, including depression, anxiety, posttraumatic stress disorder, psychotic spectrum disorders, and substance use disorders. The authors compared rates among cohorts defined by the occurrence of a medically treated, and typically more severe, TBI with rates of psychiatric conditions in the general population.

Weaknesses in this approach are beyond the scope of this article, but the primary concern is the treatment of a selected TBI as if it were the only injury in the person's life. Indeed, previous studies of persons with a TBI treated in a hospital have found that TBI in childhood and early adulthood often precede more severe injuries requiring higher levels of care (16). This caveat aside, Ponsford and colleagues (15) concluded that depression and anxiety disorders, as well as posttraumatic stress disorder, emerged at elevated rates soon after injury. Preinjury behavioral health problems predisposed individuals to postinjury diagnoses, but development of new-onset affective disorders exceeded expectations. These investigators also concluded that the frequency of psychotic spectrum disorders did not exceed what would be expected in the general population, although this finding is at odds with population-based studies, as described below. Because of the high incidence of preexisting substance use disorders in injury populations and because some of the most severely injured individuals are prevented from resuming substance misuse, the authors concluded that there was a decline in incidence, which is also at odds with epidemiological studies that account for TBIs across the life span (17).

Population-based studies examining behavioral health disorders that occur after onset of a person's first TBI suggest that there are significant associations, although causality cannot be ascertained. Sariaslan and colleagues (11) compiled medical, behavioral health, and social service records for 1.1 million Swedish citizens born between 1973 and 1983, which were subsequently accessed through 2013. All persons who were medically diagnosed as having a TBI before age 25 were evaluated for the likelihood of receiving any psychiatric services or being hospitalized for a psychiatric diagnosis. Compared with the general population, those with a history of TBI were 37% more likely to receive psychiatric services and 69% more likely to be hospitalized than persons without TBI, after controlling for gender, birth order, birth year, individual and parental educational achievement levels, parental income, parental lifetime criminal and psychiatric histories, and being raised with a single mother as the head of household. When these individuals were compared with siblings who did not have a TBI, the relative likelihood of receiving psychiatric services or of being hospitalized declined only slightly to 31% and 57%, respectively.

A population-based study in Denmark (18) analyzed medical and psychiatric registry data for 1.4 million citizens born between 1977 and 2000 and followed their cases until 2011. In total, 114,000 individuals had a hospital record for a TBI and no previous psychiatric history. After the study controlled for gender, age, year, presence of a family psychiatric history, epilepsy, infections, and autoimmune diseases, those with a history of TBI were 65% more likely to receive a diagnosis of schizophrenia, 59% more likely to receive a diagnosis of depression, and 28% more likely to receive a diagnosis of bipolar disorder. When individuals with a history of TBI were compared with persons who had fractures that did not involve the skull or spine, their likelihood of receiving a diagnosis of schizophrenia or depression remained significantly higher. Thus, together, these large, population-based studies indicate that multiple behavioral health problems are associated with an early-life TBI, particularly in childhood and as a young adult. Again, although causality cannot be ascertained, the strength of the relationship while controlling for multiple social factors and the greater association with behavioral health problems than for individuals with orthopedic injuries or uninjured siblings increases suspicion of a causal relationship.

Multiple, large-scale studies of suicide have identified TBI as a significant risk factor (19). Fazel and colleagues (20) reported that, among 2.6 million Swedish citizens, those with a history of medically attended TBI were more than three times more likely to commit suicide compared with persons with no history of TBI; when compared with uninjured siblings, they were still more than twice as likely. A population study of 7.4 million Danish residents found that those with a history of TBI were more than 2.5 times more likely to commit suicide compared with persons with no history of TBI. If the TBI was severe, this likelihood rose to almost 3.5 times more likely (21). A review of electronic health records from eight large U.S. health care systems found that individuals with a diagnosis of TBI were almost nine times more likely to commit suicide than other enrollees of similar age, sex, psychiatric diagnosis, and history of substance use disorder (22). No other medical condition had a higher likelihood of suicide.

Corrigan and Adams (23) recently described how the opioid epidemic created a “perfect storm” for persons with TBI. Several studies of veterans have found that those with TBI were more likely to be prescribed opioids than those without TBI; as many as 70% of persons receiving inpatient rehabilitation for a primary diagnosis of TBI received an opioid during his or her hospital stay (24–27). Compounding this greater likelihood of being prescribed an opioid is the greater vulnerability to substance use disorder (14, 17), including opioid misuse (28), and greater challenges in substance use disorder treatment, as discussed below. Corrigan and Adams (23) concluded that “clinical practitioners can proactively mitigate potential opioid use problems by identifying high risk populations, which we argue, includes individuals with a lifetime history of TBI.”

WHY WOULD TBI CAUSE BEHAVIORAL HEALTH PROBLEMS?

The fingerprint of TBI is that the frontal areas of the brain, including the frontal lobes, are the most likely to be injured, regardless of the location of the point of impact to the head. Once there is enough force from a blow to the head, from shaking, or from a blast to cause the brain to jiggle within the cranial vault, then bony ridges on the undersurface of the skull cause damage to the frontal lobes and anterior tips of the temporal lobes (29, 30). Shearing and tearing of neuronal pathways connecting the midbrain, basal ganglia, and prefrontal cortex also occur if there is sufficient force to the brain, regardless of the actual point of impact (31). Thus, whether because of contusion or shearing, and wherever else there may be damage to the brain, there is also damage in the frontal areas. The frontal lobes of the brain are essential to uniquely human functions, including the executive functions that regulate thinking, behavior, and emotional expression. These functions include attention and processing speed, learning and memory, problem solving, initiation, inhibition of impulse, planning and organization, mental flexibility, and self-awareness. Executive functions are essential to learning a new skill, initiating behavior change, or regulating one’s feelings and actions. It is worth noting that anoxic and hypoxic brain injury, such as that which occurs in drug overdoses or choking during intimate partner violence, also cause weaknesses in executive functions (23).

Several groups of investigators have found evidence from animal studies that TBI, particularly in childhood, may predispose individuals to adult substance use disorders (14, 17). Karelina and colleagues (32) proposed that one mechanism of this effect may be disruption of the dopaminergic system during adolescence, a key period in its development. Activity of the dopaminergic system is a well-known substrate of substance use disorders (33). Although Weil and Karelina (34) allowed that there can be direct damage to the neural projections into the prefrontal cortex, they posited that a more likely consequence is initial hyperstimulation of dopaminergic function caused by the injury, followed by chronic suppression of dopamine expression persisting into adulthood. This effect may parallel the suspected mechanism of vulnerability to addiction caused by exposure to alcohol and other drugs early in life. These investigators have also posited that, in some cases, neuroinflammatory processes caused by the injury do not return to normal levels, creating a cyclic effect whereby neuroinflammation depresses dopaminergic function, which increases the drive for alcohol, the consumption of which increases neuroinflammation.

Weil and colleagues (17) concluded that strong evidence from animal studies for an underlying mechanism, combined with moderately strong evidence of an association in human epidemiologic studies, support the conclusion that TBI occurring early in life can increase the incidence of alcohol use disorders. Cannella and colleagues (14) came to a similar conclusion with regard to adult substance use disorders more broadly. They, too, posited that TBI in adolescence has a key role in interrupting the development of the dopaminergic system, resulting in adult predisposition to addiction. This work provides substantial evidence for a link between TBI and substance use disorders; however, the effect of TBI may not be limited to addictive behaviors. Other studies examining how persistent neuroinflammation interacts with stress have concluded that neuroinflammation can cause depression and anxiety and, possibly, psychotic spectrum disorders (35).

TBI IN TREATMENT OF BEHAVIORAL HEALTH CONDITIONS

Persons with TBI often experience other medical conditions as well as multiple behavioral health disorders (36). Common health problems among persons with TBI include headaches (37), fatigue (38), sleep disturbance (39), balance problems (40), pituitary dysfunction (41), seizure disorders (42), and vision abnormalities (43). These health problems typically necessitate medication, often presenting additional considerations when initiating pharmacologic treatment for a behavioral health problem. Increased sensitivity to side effects, such as sedation, may complicate the presence of multiple medications and, in turn, may have a disproportionate effect on alertness, cognitive function, and behavioral control. Many of these comorbid medical conditions also will be exacerbated by stress (e.g., headache, sleep disturbance, seizure regulation), introducing additional complications during times of crisis. A holistic approach to a client's medical presentation and, particularly, pharmacologic requirements may be essential.

It is well established that persons with substance use disorders and TBI are also quite likely to be experiencing other psychiatric conditions. Several years ago, a study was conducted in one state's substance use disorder system in which all clients statewide entering treatment during a 1-year period were screened for a lifetime history of loss of consciousness due to TBI (44). For the almost 8,000 clients screened, as the number of TBIs increased, so did the likelihood of having mental health conditions, including affective disorders, suicidal behavior, and hallucinations, and of being on a prescription medication for a psychiatric diagnosis. Multiple studies before and since have confirmed these findings (45–48). Consistent with this relationship, studies have found that persons receiving treatment for co-occurring severe mental illness and substance use disorders tend to have a high prevalence of TBI: 60% of clients in a study of largely homeless recipients of treatment for co-occurring conditions had at least one TBI with loss of consciousness in their lifetime (49). Despite the marked morbidity in this population, those with a history of TBI had worse psychiatric symptomatology and greater likelihood of co-occurring personality disorders and posttraumatic stress disorder. More than 70% of treatment recipients in a rural program for co-occurring disorders had at least one TBI with loss of consciousness (50). In this cohort, personality disorders were significantly more likely among those with TBI.

A study of patients enrolled in one integrated treatment program for co-occurring disorders found that clients with a history of TBI were as likely to benefit from enrollment as clients without such a history (50). However, professional staff expressed lower prognostic expectations for clients with a TBI history if the programmatic structure was removed. Staff unaware of the clients' history of TBI identified a greater need for ongoing community supports among those with a positive history. Although it is good practice to identify what elements of a person's environment—social and physical—may enhance or impede improvement, this evaluation is essential for persons with TBI. Explicitly addressing these influences in treatment planning and identifying long-term natural supports that will assist with sustaining positive change must be incorporated into the treatment approach.

The corollary to the greater influence of the external environment is the recognition that clients with a history of TBI will also be more susceptible to internal states that enhance or detract from successful behavior change. For instance, a recent study of methamphetamine-induced cravings found that the effectiveness of naltrexone increased with diminished higher-level thinking skills (51). The practical implications for behavioral health care are that medication-based treatments may be even more important. Furthermore, more time will be required to weaken stimulus-response patterns and consolidate healthy lifestyle changes. Although a review of pharmacologic approaches to treatment of behavioral health conditions is beyond the scope of the present article, clients with TBI who have behavioral health conditions for which there is evidence of pharmacologic benefit should be given the opportunity of a trial (52).

WORKFORCE IMPLICATIONS

The unique fingerprint of TBI described earlier makes clear that this condition has a significant interaction with the occurrence, manifestation, and recovery from behavioral health disorders. A pressing policy implication is to improve the skill set of the behavioral health workforce to better identify the presence of TBI and be able to respond to common neurologic impairments. Specific skills are the ability to screen for a history of TBI as a routine component of initial evaluations; recognize the behavioral consequences of TBI; and accommodate executive functioning weaknesses in communication, relationship building, and treatment planning.

Minimally, TBI is a condition that requires identification by behavioral health professionals. Several brief, easy-to-use, reliable, valid, and standardized methods are available for eliciting a client's lifetime history of TBI (53). Screening techniques can be taught in 1-hour training sessions. Free training sessions are available online. Specific techniques, most of which are also available at no cost, can require as little as 3–5 minutes to administer (53). Identification underpins the ability to accommodate the effects of TBI; thus, every behavioral health professional should know the extent of a client's lifetime exposure to TBI as one critical component of client history.

Perhaps the single most important implication of TBI for treatment of behavioral health conditions is that professionals recognize neurobehavioral deficits that can arise from impairment to executive function and accommodate these weaknesses in their treatment planning and execution. Among several specific issues to address is recognition of the "cognitive load" that some treatments require. What is expected from the treatment approach in terms of new learning—facts, rules, or routines? How can a clinician assist a client with TBI who may have attention or memory problems in acquiring this information and recalling it when needed? Is orally presented information reinforced with written materials? Is the environment noisy or busy and, thus, a source of distraction for a client with problems sustaining attention? How long are treatment activities, whether individual sessions or groups, and do they accommodate a person with a limited attention span? Is information presented or discussed at a pace that allows someone with slower information-processing abilities to stay abreast? Although much treatment of behavioral health conditions relies on group interventions, professionals must ensure that the structure and content remain accessible to all group members, especially those with relative weaknesses in concentration, learning, and memory.

Another consequence of not recognizing that client behavior may arise from neurological deficits is misattribution of a client's behavior by both peers and professionals. For instance, a client with a TBI who is unaware that she or he talks too much in group may elicit the conclusion from a peer that "she thinks her problems are more important than mine" or "he's just trying to waste our time." Clinicians, like most people, tend to assume that individuals recognize the impact of their behavior on others, but clients with a history of TBI that has altered their social cognition may not have this awareness. The negative misattribution arises from the assumption that the client is persisting with the behavior despite its impact on others. Another common misattribution among professionals is to assume that treatment noncompliance reflects a client's motivation to change. For a person with a history of TBI, a late arrival or missed appointment could just as easily result from poor memory, organization, or planning as it can from low commitment to treatment. The source of noncompliance must be evaluated before a conclusion is reached or a consequence is determined. When noncompliance arises from executive function weaknesses, the relationship with a treating professional will be better served by problem solving to figure out a compensatory strategy than by a consequence that presumes low motivation.

The accommodations to treatment suggested here reflect broad principles that are known to enhance treatment in general and are likely to also benefit clients who have not had TBIs. Examining our treatment procedures and settings to identify how cognitive weaknesses might be barriers to treatment will benefit many clients in community programs. Recognizing that not all behavior is a function of motivation but can sometimes arise from neurological deficits is a needed insight in professional practice. Many clients in community programs have multiple medical and behavioral health conditions. Thinking and treating holistically will benefit complicated cases; recognizing that TBI is a source of complication is a positive step. Finally, thinking more systematically about how we can support insight with positive internal and external influences is best practice, regardless of a client's risk factors.

DISCUSSION

A TBI is damage to the brain caused by an external force. Although it is most common for the head to be struck by or against an object, being shaken violently or exposed to an explosion can also cause a TBI. The general public now knows that TBI and concussions exist, although they may not know that a concussion is a TBI. Because of the public's poor understanding, it is incumbent upon professionals to determine whether a client has a sufficient history of TBI such that he or she may be experiencing consequences that will affect the treatment process. This expectation of professionals is particularly salient among behavioral health professionals. It is reasonable to expect that half of the adult clients treated in community mental health programs will have had at least one TBI with loss of consciousness in their lifetime, and one in six will have had a moderate or severe TBI (47). Both rates are more than twice what would be expected among noninstitutionalized adults.

The high prevalence of TBI in behavioral health settings alone should be reason for improving our ability to recognize it among our clients. Furthermore, the magnitude of increased risk for suicide and the confluence with the opioid epidemic also should motivate us to better identify clients with a history of TBI. However, as briefly described in this article, the connection with behavioral health does not stop with vulnerability; the proclivity for damage to the frontal areas of the brain interacts with our treatment approaches such that treatment is less effective for these clients.

The fingerprint of TBI is damage to the frontal areas of the brain, which impairs executive functions that regulate thinking, behavior, and emotional expression and that are critical to success in treatment. A follow-up investigation to Project MATCH (Matching Alcoholism Treatments to Client Heterogeneity) found that persons with cognitive impairments such as those described in this article were more likely to prematurely terminate treatment and are often classified as noncompliant (54). Treatment termination was often preceded by low expectations for benefiting from treatment, which is often evident clinically when the cognitive demands of treatment exceed a client's capabilities. It is also plausible that misattribution of motives by peers and professionals undermines the expectation of benefit from treatment.

The recommendations made here for workforce training are derived from evidence and are suggested as best practices that can make systemic improvements in the treatment of persons with TBI and behavioral health conditions. The recommendations have low potential for iatrogenic effects. Clinical experience indicates that identifying a history of TBI is viewed positively by most clients, who often express sentiments such as, "At least I'm not dumb" or "I thought I was just bad." Identification often increases motivation to make changes while allowing professionals to implement the other recommendations.

Additional research is needed on the interaction between TBI and behavioral health. Continuing to study the underlying mechanism between injury and vulnerability has the potential to result in the discovery of new treatments to either prevent or ameliorate the underlying source of risk. There are multiple opportunities to study how proven behavioral health interventions may need to be modified to better serve persons with TBI. Research on screening and brief intervention for persons with TBI is a case in point that demonstrates how treatment can be improved (55, 56). Medication-based treatment would seem to be a high-priority area for understanding how TBI may affect proven approaches. Evaluation research is also needed to confirm that the skills that will be needed among behavioral health professionals can be conveyed through training and that outcomes actually improve as a result.

TBI poses a substantial public health burden. As indicated, the annual cost of TBI to society is estimated to approach $1 billion (2) but is certainly substantially higher (3, 4). A better understanding of how mild TBIs in childhood can affect adult health and behavior could cause this estimate to skyrocket. As an example, Sariaslan and colleagues (11) estimated that the population-attributable fraction (the proportional reduction in morbidity that would occur if a risk factor were eliminated) was 5.5% for psychiatric hospitalizations and 3.1% for any psychiatric visit. These implied costs to society are reason enough for behavioral health care to systematically address TBI, but the potential benefit for a substantial portion of clients is even more compelling.

Among behavioral health providers who treat persons with TBI, it is recognized that the disconnect between the intention to change behavior and success in doing so is even greater than for clients without a history of TBI. Whereas most treatments start by seeking insight into the need to change behavior, behavioral health care also recognizes the importance of a person's social environment in encouraging and sustaining changed behavior, the role of internal states (impulses, drives, stress) in improving the chances of successful change, and the critical role that sustaining changed behavior plays in consolidating treatment gains.

CONCLUSIONS

TBI occurs when brain function is disrupted by an external force to the head. It is prevalent in society and even more common among persons with behavioral health problems. This association is evident for affective, psychotic spectrum, and substance use disorders. Regardless of where the blow to the head occurs, the fingerprint of TBI is damage to the frontal areas of the brain, which frequently results in impaired cognitive abilities and higher-level executive functioning deficits. These deficits reduce success in treatment for people with a sufficient history of TBI. The behavioral health workforce needs additional knowledge and skills to improve outcomes for this population, including the ability to identify problematic histories of TBI and to accommodate neurological deficits in treatment.

AUTHOR AND ARTICLE INFORMATION

Department of Physical Medicine and Rehabilitation, The Ohio State University, Columbus. Send correspondence to Dr. Corrigan (johncorrigan1@me.com).

The National Association of State Mental Health Program Directors (NASMHPD) contracted with the author to create this work (contract no. CA-3011.3-RPI-01). This work was developed under Task 2.2 of NASMHPD's Technical Assistance Coalition contract/task order HHSS283201200021I-HHS28342003T and was funded by the Center for Mental Health Services and the Substance Abuse and Mental Health Services Administration of the Department of Health and Human Services through the NASMHPD.

The author reports no financial relationships with commercial interests.

Received November 13, 2019; revision received June 19, 2020; accepted December 8, 2020; published online February 24, 2021.

REFERENCES

1. Taylor CA, Bell JM, Breiding MJ, et al: Traumatic brain injury–related emergency department visits, hospitalizations, and death—United States, 2007 and 2013. MMWR Surveill Summ 2017; 66:1–16
2. Gooch CL, Pracht E, Borenstein AR: The burden of neurological disease in the United States: a summary report and call to action. Ann Neurol 2017; 81:479–484
3. Whiteneck GG, Cuthbert JP, Corrigan JD, et al: Prevalence of self-reported lifetime history of traumatic brain injury and associated disability: a statewide population-based survey. J Head Trauma Rehabil 2016; 31:E55–E62
4. Yi H, Corrigan JD, Singichetti B, et al: Lifetime history of traumatic brain injury and current disability among Ohio adults. J Head Trauma Rehabil 2018; 33:E24–E32
5. Menon DK, Schwab K, Wright DW, et al: Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil 2010; 91:1637–1640
6. Ruff RM, Iverson GL, Barth JT, et al: Recommendations for diagnosing a mild traumatic brain injury: a National Academy of Neuropsychology education paper. Arch Clin Neuropsychol 2009; 24:3–10
7. Johnson VE, Stewart W, Arena JD, et al: Traumatic brain injury as a trigger of neurodegeneration. Adv Neurobiol 2017; 15:383–400
8. Guskiewicz KM, McCrea M, Marshall SW, et al: Cumulative effects associated with recurrent concussion in collegiate football players: the NCAA Concussion Study. JAMA 2003; 290:2549–2555

9. McKinlay A, Grace RC, Horwood LJ, et al: Long-term behavioural outcomes of preschool mild traumatic brain injury. Child Care Health Dev 2010; 36:22–30
10. Corrigan JD, Bogner J, Holloman C: Lifetime history of traumatic brain injury among persons with substance use disorders. Brain Inj 2012; 26:139–150
11. Sariaslan A, Sharp DJ, D'Onofrio BM, et al: Long-term outcomes associated with traumatic brain injury in childhood and adolescence: a nationwide Swedish cohort study of a wide range of medical and social outcomes. PLoS Med 2016; 13:e1002103
12. McKinlay A, Dalrymple-Alford JC, Horwood LJ, et al: Long term psychosocial outcomes after mild head injury in early childhood. J Neurol Neurosurg Psychiatry 2002; 73:281–288
13. Weil Z, Karelina K, Gaier KR, et al: Juvenile traumatic brain injury increases alcohol consumption and reward in female mice. J Neurotrauma 2016; 33:895–903
14. Cannella LA, McGary H, Ramirez SH: Brain interrupted: early life traumatic brain injury and addiction vulnerability. Exp Neurol 2019; 317:191–201
15. Ponsford J, Alway Y, Gould KR: Epidemiology and natural history of psychiatric disorders after TBI. J Neuropsychiatry Clin Neurosci 2018; 30:262–270
16. Corrigan JD, Bogner J, Mellick D, et al: Prior history of traumatic brain injury among persons in the Traumatic Brain Injury Model Systems National Database. Arch Phys Med Rehabil 2013; 94: 1940–1950
17. Weil ZM, Karelina K, Corrigan JD: Does pediatric traumatic brain injury cause adult alcohol misuse: combining preclinical and epidemiological approaches. Exp Neurol 2019; 317:284–290
18. Orlovska S, Pedersen MS, Benros ME, et al: Head injury as risk factor for psychiatric disorders: a nationwide register-based follow-up study of 113,906 persons with head injury. Am J Psychiatry 2014; 171:463–469
19. Simpson GK, Brenner LA: Suicide Prevention after Neurodisability: An Evidence-Informed Approach. New York, Oxford University Press, 2019
20. Fazel S, Wolf A, Pillas D, et al: Suicide, fatal injuries, and other causes of premature mortality in patients with traumatic brain injury: a 41-year Swedish population study. JAMA Psychiatry 2014; 71:326–333
21. Madsen T, Erlangsen A, Orlovska S, et al: Association between traumatic brain injury and risk of suicide. JAMA 2018; 320:580–588
22. Ahmedani BK, Peterson EL, Hu Y, et al: Major physical health conditions and risk of suicide. Am J Prev Med 2017; 53:308–315
23. Corrigan JD, Adams RS: The intersection of lifetime history of traumatic brain injury and the opioid epidemic. Addict Behav 2019; 90:143–145
24. Bertenthal D, Yaffe K, Barnes DE, et al: Do postconcussive symptoms from traumatic brain injury in combat veterans predict risk for receiving opioid therapy for chronic pain? Brain Inj 2018; 32:1188–1196
25. Seal KH, Bertenthal D, Barnes DE, et al: Traumatic brain injury and receipt of prescription opioid therapy for chronic pain in Iraq and Afghanistan veterans: do clinical practice guidelines matter? J Pain 2018; 19:931–941
26. Adams RS, Larson MJ, Meerwijk EL, et al: Postdeployment polytrauma diagnoses among soldiers and veterans using the Veterans Health Affairs Polytrauma System of Care and receipt of opioids, nonpharmacologic, and mental health treatments. J Head Trauma Rehabil 2019; 34:167–175
27. Hammond FM, Barrett RS, Shea T, et al: Psychotropic medication use during inpatient rehabilitation for traumatic brain injury. Arch Phys Med Rehabil 2015; 96(suppl 8):S256–S273.e14.
28. Ilie G, Adlaf EM, Mann RE, et al: Associations between a history of traumatic brain injuries, and current cigarette smoking, substance use, and elevated psychological distress in a population sample of Canadian adults. J Neurotrauma 2015; 32:1130–1134
29. Bigler ED, Maxwell WL: Neuropathology of mild traumatic brain injury: relationship to neuroimaging findings. Brain Imaging Behav 2012; 6:108–136
30. Courville CB: Pathology of the Central Nervous System, 3rd ed. Mountain View, CA, Pacific Press Publishing Association, 1950
31. Yuh EL, Gean AD: Structural neuroimaging; in Brain Injury Medicine: Principles and Practice, 2nd ed. Edited by Zasler ND, Katz DI, Zafonte RD, et al. New York, Demos Medical Publishing, 2012
32. Karelina K, Gaier KR, Weil ZM: Traumatic brain injuries during development disrupt dopaminergic signaling. Exp Neurol 2017; 297:110–117
33. Martinez D, Gil R, Slifstein M, et al: Alcohol dependence is associated with blunted dopamine transmission in the ventral striatum. Biol Psychiatry 2005; 58:779–786
34. Weil ZM, Karelina K: Traumatic brain injuries during development: implications for alcohol abuse. Front Behav Neurosci 2017; 11:135
35. Tapp ZM, Godbout JP, Kokiko-Cochran ON: A tilted axis: maladaptive inflammation and HPA axis dysfunction contribute to consequences of TBI. Front Neurol 2019; 10:345
36. Bogner J, Corrigan JD, Yi H, et al: Lifetime history of traumatic brain injury and behavioral health problems in a population-based sample. J Head Trauma Rehabil 2020; 35:E43–E50
37. Stacey A, Lucas S, Dikmen S, et al: Natural history of headache five years after traumatic brain injury. J Neurotrauma 2017; 34:1558–1564
38. Ponsford J, Schönberger M, Rajaratnam SM: A model of fatigue following traumatic brain injury. J Head Trauma Rehabil 2015; 30: 277–282
39. Nakase-Richardson R: Improving the significance and direction of sleep management in traumatic brain injury. J Head Trauma Rehabil 2016; 31:79–81
40. Perry SB, Woollard J, Little S, et al: Relationships among measures of balance, gait, and community integration in people with brain injury. J Head Trauma Rehabil 2014; 29:117–124
41. Srinivasan L, Roberts B, Bushnik T, et al: The impact of hypopituitarism on function and performance in subjects with recent history of traumatic brain injury and aneurysmal subarachnoid haemorrhage. Brain Inj 2009; 23:639–648
42. Bushnik T, Englander J, Wright J, et al: Traumatic brain injury with and without late posttraumatic seizures: what are the impacts in the post-acute phase: a NIDRR Traumatic Brain Injury Model Systems study. J Head Trauma Rehabil 2012; 27:E36–E44
43. Hunt AW, Mah K, Reed N, et al: Oculomotor-based vision assessment in mild traumatic brain injury: a systematic review. J Head Trauma Rehabil 2016; 31:252–261
44. Walker R, Cole JE, Logan TK, et al: Screening substance abuse treatment clients for traumatic brain injury: prevalence and characteristics. J Head Trauma Rehabil 2007; 22:360–367
45. Vaughn MG, Salas-Wright CP, John R, et al: Traumatic brain injury and psychiatric comorbidity in the United States. Psychiatr Q 2019; 90:151–158
46. Sayko Adams R, Corrigan JD, Mohr BA, et al: Traumatic brain injury and postdeployment binge drinking among male and female army active duty service members returning from Operation Enduring Freedom/Operation Iraqi Freedom. J Neurotrauma 2017; 34:1457–1465
47. Corrigan JD, Mysiw WJ: Substance abuse among persons with TBI; in Brain Injury Medicine: Principles and Practice, 2nd ed. Edited by Zasler ND, Katz DI, Zafonte RD, et al. New York, Demos Medical Publishing, 2012
48. Parry-Jones BL, Vaughan FL, Miles Cox W: Traumatic brain injury and substance misuse: a systematic review of prevalence and

outcomes research (1994–2004). Neuropsychol Rehabil 2006; 16: 537–560
49. McHugo GJ, Krassenbaum S, Donley S, et al: The prevalence of traumatic brain injury among people with co-occurring mental health and substance use disorders. J Head Trauma Rehabil 2017; 32:E65–E74
50. Corrigan JD, Deutschle JJ Jr: The presence and impact of traumatic brain injury among clients in treatment for co-occurring mental illness and substance abuse. Brain Inj 2008; 22:223–231
51. Lim AC, Grodin EN, Green R, et al: Executive function moderates naltrexone effects on methamphetamine-induced craving and subjective responses. Am J Drug Alcohol Abuse 2020; 46:565–576
52. Leshner AI, Mancher M (eds): Medications for Opioid Use Disorder Save Lives. Washington, DC, National Academies Press, 2019
53. Dams-O'Connor K, Cantor JB, Brown M, et al: Screening for traumatic brain injury: findings and public health implications. J Head Trauma Rehabil 2014; 29:479–489
54. Bates ME, Pawlak AP, Tonigan JS, et al: Cognitive impairment influences drinking outcome by altering therapeutic mechanisms of change. Psychol Addict Behav 2006; 20:241–253
55. Bogner JB, Corrigan JD: Interventions for substance misuse following TBI: a systematic review. Brain Impair 2013; 14:77–91
56. Corrigan JD, Bogner J, Hungerford DW, et al: Screening and brief intervention for substance misuse among patients with traumatic brain injury. J Trauma 2010; 69:722–726

Submissions Invited for Culture & Mental Health Services Column

A new column in *Psychiatric Services,* Culture & Mental Health Services, edited by Roberto Lewis-Fernández, M.D., aims to clarify the ways that culture shapes the utilization, delivery, and organization of mental health services. Submissions may examine the influence of culture at the level of the individual seeking care (e.g., the impact of a person's cultural views of illness on treatment choice and level of engagement), the provider (e.g., the role of implicit racial-ethnic biases on service recommendations), the program (e.g., how local socioeconomic and organizational factors influence the package of services offered at a clinic), or the mental health system (e.g., how political forces affect reimbursement structures that determine availability of services). Dr. Lewis-Fernández welcomes papers that focus on aspects of culture related to interpretation (meaning making), social group identity (e.g., race-ethnicity, language, and sexual orientation), and social structures and systems. The goal of the column is to make visible the social-contextual frameworks that shape care. Papers, limited to 2,400 words, may be submitted online as columns via ScholarOne Manuscripts at mc.manuscriptcentral.com/appi-ps. The cover letter should specify that the submission is for the Culture & Mental Health Services column.

J Head Trauma Rehabil
Vol. 37, No. 1, pp. 2–4

Preface

OPEN

Brain Injury and Intimate Partner Violence

Angela Colantonio, PhD, OT Reg. (Ont.); Eve M. Valera, PhD

We wish to thank Dr John Corrigan for the invitation to orchestrate this topical issue on brain injury (BI) resulting from intimate partner violence (IPV). The articles in this issue address a long-neglected gap in research, education, and practice in both the IPV and BI literature. We include articles on traumatic brain injury (TBI) caused by external forces to the head and also potential hypoxic-ischemic brain injuries (HIBIs) from strangulation assaults. With 1 in 3 women globally reporting physical or sexual IPV, and up to 92% of blows being to the head, face, or neck,[1] it is imperative that practitioners, decision/policy makers, and affected women be aware of this co-occurrence of IPV and BI and have access to necessary supports. IPV has been called the "shadow" or "parallel pandemic" to COVID-19, with BIs from IPV being recognized as a significantly increased concern now and for the foreseeable future.[2,3] Furthermore, addressing violence and abuse among women with TBI has been identified as a research and practice priority including among women with lived experience of TBI and IPV.[4,5] As such, the importance of the articles in this issue of the *Journal of Head Trauma Rehabilitation* (*JHTR*) should be particularly apparent as they highlight a range of topics pertaining to IPV-related BI, including prevalence data, clinical characteristics, and correlates, promising/tailored interventions as well as health systems data with national policy relevance.

UNDERSTANDING CHARACTERISTICS AND OUTCOMES OF NONFATAL STRANGULATION

This issue describes characteristics and correlates of nonfatal strangulation. We start with this to stress the importance of recognizing the potential of acquired BIs, or HIBIs, occurring from a strangulation assault. First, Bergin and colleagues[6] recount information from women presenting for care to a community-based emergency department. Victims of nonfatal strangulation most commonly reported not only symptoms of neck pain and headaches but also signs of more severe injury such as loss of consciousness, dysphagia, and dysphonia. In addition, Valera and colleagues[7] provide the first report of assessment of strangulation-related alterations in consciousness and relate them to objective measures of cognitive and psychological functioning. The data show relationships between a history of strangulation-related alterations in consciousness and working memory, long-term memory, depression, and posttraumatic stress symptoms.[7]

INCREASING OUR UNDERSTANDING OF NEUROBEHAVIORAL SYMPTOMS IN BOTH SURVIVORS AND PERPETRATORS

To further understand symptoms of women from a lifetime of trauma perspective, Saadi and colleagues[8] examined the relations between child abuse and an IPV-related BI score reflecting neurobehavioral outcomes. They show that childhood trauma is positively associated with emotional and somatic neurobehavioral symptoms independent of BI; furthermore, they found that BI is positively associated with cognitive neurobehavioral symptoms in women who had experienced IPV-related BI. These data underscore the need to consider neurobehavioral symptoms in the context of the entire life experience of women rather than isolated to outcomes of BIs. Examining perpetrators of IPV, Portnoy and colleagues[9] found that persistent postconcussive symptoms significantly predicted IPV perpetration after controlling for other common

---

This work was supported in part by the Canada Research Chairs Program for Dr Colantonio. Dr Valera acknowledges current funding (RO1 NS112694-01).

The authors declare no conflicts of interest.

DOI: 10.1097/HTR.0000000000000763

predictors. These data highlight the importance of evaluating and addressing postconcussive symptoms to decrease the risk of IPV perpetration.

UNDERSTANDING NEUROIMAGING CORRELATES OF IPV-RELATED BI

Adding to the growing number of IPV-related neuroimaging articles,[10–12] Likitlersuang and colleagues[13] conducted a pilot study that included groups of women who have sustained either IPV-related or other trauma-related TBI. Their data suggest that there may be effects on cortical thickness depending on whether TBIs were from IPV or other types of trauma.

PREVALENCE OF IPV-RELATED BI

Offering a global perspective, this issue presents novel contributions concerning the prevalence of IPV-related BI in 3 countries. Manoranjan and colleagues[14] report a high suspicion of lifetime IPV-related TBI among 29% of adult women presenting to an Acquired Brain Injury Clinic in Ontario, Canada, with confirmed or suspected concussion. Gabbe and colleagues[15] compared outcomes of major trauma patients with IPV-related BI with other interpersonal violence–related BI captured by a population-based statewide trauma registry in Australia. The findings reveal a higher proportion of IPV-related major traumas in women, with more severe and poorer long-term outcomes, including employment, than in persons affected by other types of violence.[15] Finally, Saleem and colleagues[16] report on IPV-related TBI from a New York Community Justice Center. Although all women who reported IPV had sustained a partner-related BI, only 40% of these women screened positive on a common BI screener (the HELPS). The authors noted that refugee status was associated with the number of IPV-related BIs, highlighting the importance of carefully assessing for BIs in this population.

ADDRESSING THE IMPACT OF IPV ON BOTH SERVICE USERS AND PROVIDERS DURING COVID-19

Two studies addressed the impact on service users and providers of IPV during the COVID-19 pandemic–one study from the perspective of survivors, executive directors/managers, frontline workers, and employer/union representatives,[17] and the other from an emergency summit that involved a diverse set of stakeholders from a national IPV-TBI Knowledge to Practice Network.[18] These studies report increased rates and severity of IPV, increased risks and complex challenges to mental health for service providers, as well as impact on employment for survivors. Key priorities identified include flexibility and adaptability of services through the use of technology; increased outreach; trauma-informed, anti-racist, equitable systems of care; the need for cross-pollination of knowledge between disciplines; and integrated and coordinated care at the system level. IPV-TBI resource materials from the summit are available in the Abused and Brain Injured Toolkit (www.abitoolkit.ca).[19]

PROMISING NEW DEVELOPMENTS IN PROGRAMMING AND KNOWLEDGE TRANSFER

Finally and critically, this issue highlights the impact of a promising health advocacy intervention, CARE (Connect, Acknowledge, Respond, and Evaluate),[20] revealing improvements in agencies' and advocates' provision of instructional and functional social support to survivors of IPV-related BI. Survivors increased their knowledge, personal validation, and agency. These tools can be downloaded from the Centre for Partner Inflicted Brain Injury website (www.odvn.org/brain-injury). Also, a letter by Katherine Snedaker[21] of Pink Concussion (www.pinkconsussions.com) provides information about the Partner Inflicted Brain Injury (PIBI) task force created in 2018. The task force meets monthly and serves as a focal point for professional education and networking that has led to collaborative research and knowledge transfer activities.[21]

We are very excited about this issue and extend sincere gratitude to all the contributors, the *JHTR* editorial board, and the reviewers for making this possible. The articles are highly relevant to the rehabilitation field as persons with disabilities, including persons with BI, are at risk of IPV and victimization. Women, in particular, have reported susceptibility to violence and abuse[22] and, unfortunately, are often overlooked in the context of recognizing BI in IPV survivors. We are optimistic that the articles in this issue will further the field and prepare the way for additional research that will expand knowledge of IPV-related BI to other marginalized groups (eg, transgender women) yet to be examined.

Angela Colantonio, PhD, OT Reg. (Ont.)
Canada Research Chair in Traumatic Brain Injury in Underserved Populations
Professor and Director
Rehabilitation Sciences Institute
Department of Occupational Science and Occupational Therapy
Temerty Faculty of Medicine
Dalla Lana School of Public Health
University of Toronto
Toronto, Ontario, Canada
Senior Scientist and Team Leader
Acquired Brain Injury & Society Team
KITE-Toronto Rehabilitation Institute-University Health Network
Toronto, Ontario, Canada

Eve M. Valera, PhD
Associate Professor in Psychiatry
Psychiatric Neuroscience Division
Department of Psychiatry
Harvard Medical School
Boston, Massachusetts
Research Scientist
Massachusetts General Hospital
Boston, Massachusetts
Issue Editors

REFERENCES

1. Haag HL, Jones D, Joseph T, Colantonio A. Battered and brain injured: traumatic brain injury among women survivors of intimate partner violence—a scoping review. *Trauma Violence Abuse.* 2019: 1524838019850623. doi:10.1177/1524838019850623
2. Valera EM. When pandemics clash: gendered violence-related traumatic brain injuries in women since COVID-19. *EClinicalMedicine.* 2020;24:100423. doi:10.1016/j.eclinm.2020.100423
3. Saleem GT, Fitzpatrick JM, Haider MN, Valera EM. COVID-19-induced surge in the severity of gender-based violence might increase the risk for acquired brain injuries. *SAGE Open Med.* 2021; 9:20503121211050197. doi:10.1177/20503121211050197
4. Harris JE, Colantonio A, Bushnik T, et al. Advancing the health and quality-of-life of girls and women after traumatic brain injury: workshop summary and recommendations. *Brain Inj.* 2012;26(2): 177–182. doi:10.3109/02699052.2011.635361
5. Haag HL, Sokoloff S, MacGregor N, Broekstra S, Cullen N, Colantonio A. Battered and brain injured: assessing knowledge of traumatic brain injury among intimate partner violence service providers. *J Womens Health (Larchmt).* 2019;28(7):990–996. doi:10.1089/jwh.2018.7299
6. Bergin A, Blumenfeld E, Anderson JC, Campbell JC, Patch M. Describing non-fatal intimate partner strangulation presentation and evaluation in a community-based hospital: partnerships between the emergency department and in-house advocates. *J Head Trauma Rehabil.* 2022;37(1):5–14.
7. Valera EM, Daugherty JC, Scott O, Berenbaum H. Strangulation as an acquired brain injury in intimate partner violence and its relationship to cognitive and psychological functioning: a pilot study. *J Head Trauma Rehabil.* 2022;37(1):15–23.
8. Saadi A, Chibnik L, Valera E. Examining the association between childhood trauma, brain injury, and neurobehavioral symptoms among survivors of intimate-partner violence: a cross-sectional analysis. *J Head Trauma Rehabil.* 2022;37(1):24–33.
9. Portnoy GA, Relyea MR, Presseau C, et al. Longitudinal analysis of persistent postconcussion symptoms, probable TBI, and intimate partner violence perpetration among veterans. *J Head Trauma Rehabil.* 2022;37(1):34–42.
10. Valera E, Kucyi A. Brain injury in women experiencing intimate partner-violence: neural mechanistic evidence of an “invisible” trauma. *Brain Imaging Behav.* 2017;11(6):1664–1677. doi:10.1007/s11682-016-9643-1
11. Valera EM, Cao A, Pasternak O, et al. White matter correlates of mild traumatic brain injuries in women subjected to intimate-partner violence: a preliminary study. *J Neurotrauma.* 2019;36(5): 661–668. doi:10.1089/neu.2018.5734
12. Daugherty JC, Verdejo-Román J, Pérez-García M, Hidalgo-Ruzzante N. Structural brain alterations in female survivors of intimate partner violence. *J Interpers Violence.* 2020: 0886260520959621. doi:10.1177/0886260520959621
13. Likitlersuang J, Brown EM, Salat DH, et al. Neural correlates of traumatic brain injury in women survivors of intimate partner violence: a structural and functional connectivity neuroimaging study. *J Head Trauma Rehabil.* 2022;37(1):E30–E38.
14. Manoranjan B, Scott T, Szasz OP, et al. Prevalence and perception of intimate partner violence-related traumatic brain injury (PIVOT). *J Head Trauma Rehabil.* 2022;37(1):53–61.
15. Gabbe BJ, Braaf S, Cameron PA, Berecki-Gisolf J. Epidemiology and 6- and 12-month outcomes of intimate partner violence and other violence-related traumatic brain injury in major trauma: a population-based trauma registry study. *J Head Trauma Rehabil.* 2022;37(1):E1–E9.
16. Saleem G, Champagne M, Haider MN, et al. Prevalence and risk factors for intimate partner physical violence-related acquired brain injury among visitors of justice center in New York. *J Head Trauma Rehabil.* 2022;37(1):E10–E19.
17. Haag HL, Toccalino D, Estrella MJ, Moore A, Colantonio A. The shadow pandemic: a qualitative exploration of the impacts of COVID-19 on service providers and women survivors of intimate-partner violence and brain injury. *J Head Trauma Rehabil.* 2022; 37(1):43–52.
18. Toccalino D, Haag HL, Estrella MJ, et al; the COVID TBI-IPV Consortium. The intersection of intimate partner violence and traumatic brain injury: findings from an emergency summit addressing system-level changes to better support women survivors. *J Head Trauma Rehabil.* 2022;37(1):E20–E29.
19. Haag H, MacGregor N, Samsa S, Sing G, Colantonio A. The abused and brain injured toolkit: understanding the intersection of intimate partner violence and traumatic brain injury. Accessed October 1, 2021. www.abitoolkit.ca
20. Kemble H, Sucaldito A, Kulow E, et al. How CARE tools are being used to address brain injury and mental health struggles with survivors of domestic violence. *J Head Trauma Rehabil.* 2022;37(1): E39–E47.
21. Snedaker KPS. Bridging the gap between IPV and brain injury. *J Head Trauma Rehabil.* 2022;37(1):E48.
22. Haag HL, Caringal M, Sokoloff S, Kontos P, Yoshida K, Colantonio A. Being a woman with acquired brain injury: challenges and implications for practice. *Arch Phys Med Rehabil.* 2016; 97(2)(suppl):S64–S70. doi:10.1016/j.apmr.2014.12.018

J Head Trauma Rehabil
Vol. 37, No. 6, pp. E428–E437

Association Between Self-Reported Disability and Lifetime History of Traumatic Brain Injury With Loss of Consciousness Among Veterans and Nonveterans in North Carolina

Kelly Sarmiento, MPH; Dana Waltzman, PhD; Jill Daugherty, PhD, MPH; Catherine A. Okoro, PhD; Scott Proescholdbell, MPH

Background: Compared with civilians, service members and veterans who have a history of traumatic brain injury (TBI) are more likely to experience poorer physical and mental health. To investigate this further, this article examines the association between self-reported history of TBI with loss of consciousness and living with 1 or more current disabilities (ie, serious difficulty with hearing, vision, cognition, or mobility; any difficulty with self-care or independent living) for both veterans and nonveterans. **Methods:** A cross-sectional study using data from the North Carolina Behavioral Risk Factor Surveillance System for 4733 veterans and nonveterans aged 18 years and older. **Results:** Approximately 34.7% of veterans residing in North Carolina reported having a lifetime history of TBI compared with 23.6% of nonveterans. Veterans reporting a lifetime history of TBI had a 1.4 times greater risk of also reporting living with a current disability (adjusted prevalence ratio = 1.4; 95% confidence interval, 1.2-1.8) compared with nonveterans. The most common types of disabilities reported were mobility, cognitive, and hearing. **Conclusions:** Compared with nonveterans, veterans who reported a lifetime history of TBI had an increased risk of reporting a current disability. Future studies, such as longitudinal studies, may further explore this to inform the development of interventions. **Key words:** *brain injury*, *cognition disorders*, *concussion*, *neurologic disorders*, *traumatic brain injury*

SUSTAINING A TRAUMATIC BRAIN INJURY (TBI) of any severity level is associated with an increased risk of having a short- or long-term disability among both civilians and veterans.[1,2] However, compared with civilians, service members and veterans who have a history of TBI are more likely to experience poorer physical and mental health (eg, depression, posttraumatic stress disorder [PTSD]) that may affect not only their ability to perform daily activities but also their overall quality of life.[3–5] Currently, estimates of the prevalence of TBI-related disability among veterans and civilians living in the United States have been challenging to obtain because of the lack of a national surveillance system.[1] A study by Selassie and colleagues,[6] published in 2008, estimated that almost 125 000 Americans per year who are hospitalized for a TBI will experience long-term disability and will likely need rehabilitative care. Furthermore, Zaloshnja and

---

***Author Affiliations:** Division of Injury Prevention, Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Atlanta, Georgia (Ms Sarmiento and Drs Waltzman and Daugherty); Disability Science and Program Team, Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities, Atlanta, Georgia (Dr Okoro); and Injury and Violence Prevention Branch, North Carolina Department of Health and Human Services, Division of Public Health, Raleigh (Mr Proescholdbell).*

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention, nor North Carolina Department of Health and Human Services.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.headtraumarehab.com).

The authors declare no conflicts of interest.

***Corresponding Author:** Kelly Sarmiento, MPH, Division of Injury Prevention, Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 4770 Buford Hwy NE, Atlanta, GA 30341 (KSarmiento@cdc.gov).*

DOI: 10.1097/HTR.0000000000000753

colleagues[7] estimated that 1.1% of the US civilian population were living with a long-term disability from TBI at the beginning of 2005. These estimates are extrapolations of state-based data on hospital discharge records and are more than a decade old. Thus, recent changes in TBI morbidity among the civilian population, such as increases in TBIs among older adults and from self-harm,[8] as well as the military conflicts from 2005 to 2018 that increased the proportion of veterans living with TBI,[9] are not accounted for in these estimates. Lack of current data on disabilities among both civilians and veterans with a history of TBI inhibits the development of targeted public health programs and services for people living with TBI.

While a causal relationship cannot be determined, survey data obtained from states that administrated questions on TBI in the Behavioral Risk Factor Surveillance System (BRFSS) allow for an examination of the relationship between lifetime history of TBI and living with a current disability.[10] Using data from the 2014 Ohio BRFSS, Corrigan and colleagues[10] found that adults with a history of TBI with loss of consciousness (LOC) were more likely to report a current disability than adults with no history of TBI with LOC. This relationship strengthened as the number of TBIs or the severity level of the worst TBI increased.[10] Using a similar methodology, this exploratory article examines the association between self-reported history of TBI with LOC and living with 1 or more current disabilities (ie, serious difficulty with hearing, vision, cognition, or mobility; any difficulty with self-care or independent living) among residents in North Carolina using data from the 2018 North Carolina BRFSS. However, this article expands upon previous findings by also reporting the association of lifetime history of TBI with LOC, hereafter referred to as lifetime history of TBI, and current disability among veterans who reside in the state.

METHODS

Study population

The BRFSS[11] is an annual, population-based representative telephone survey of noninstitutionalized US adults, aged 18 years and older in each state and the District of Columbia. The BRFSS collects information pertaining to health-related conditions and health behaviors. The BRFSS employs a complex sampling design[12]; it uses a disproportionate stratified sample design for respondents who complete the survey by landline and a random sample design for those who complete the survey by cell phone. The BRFSS also uses iterative proportional fitting to weight the data. The BRFSS data are de-identified and are considered exempt from human subjects review by the Centers for Disease Control and Prevention's (CDC's) Institutional Review Board. Analyses for this study used data from only North Carolina BRFSS respondents. The TBI-related questions were included as part of an optional module that was administered by a small number of states. It was not possible to combine data from the states that administered the optional TBI module in 2018, as the optional TBI module varied between states. In 2018, the entire sample in North Carolina ($n = 4733$) completed both the core sections of the BRFSS and the TBI module for a response rate of 43.5% (see Figure 1). For comparison, the median response rate among states/territories for the overall BRFSS is 49.9%.

Lifetime history of TBI with LOC

The TBI optional module is a modified version of the Ohio State University TBI Identification Method (OSU TBI-ID)[13] that included questions on lifetime history of TBI with LOC. After completing the core sections of the BRFSS, the TBI module was administered along with other state-added modules. For the TBI module, all respondents received the following prompt:

> For these next questions, please think about injuries you have had during your entire lifetime, especially those that affected your head or neck. It might help to remember times you went to the hospital or emergency room. Think about injuries you may have received from a car or motorcycle wreck, bicycle crash, being hit by something, falling down, being hit by someone, playing sports or an injury during military service.

This prompt was followed by the questions "Thinking about any injuries you have had in your lifetime, were you ever knocked out or did you lose consciousness?" Responses to this first question were dichotomized as yes/no. If respondents answered "yes" to the first question, they were then asked, "What was the longest time you were knocked out or unconscious?" Three answer choices, which may be used to determine TBI severity level, included the following: less than 30 minutes, between 30 minutes and 24 hours, and 24 hours or longer. Because of sample size, responses used to determine TBI severity level were dichotomized as mild (<30 minutes of LOC) or moderate/severe (≥30 minutes of LOC). In addition, the respondents who answered "yes" to the initial TBI question were then asked, "How old were you the first time you were knocked out or lost consciousness?"

Living with a current disability

The United States Department of Health & Human Services recommends the inclusion of 6 questions in the

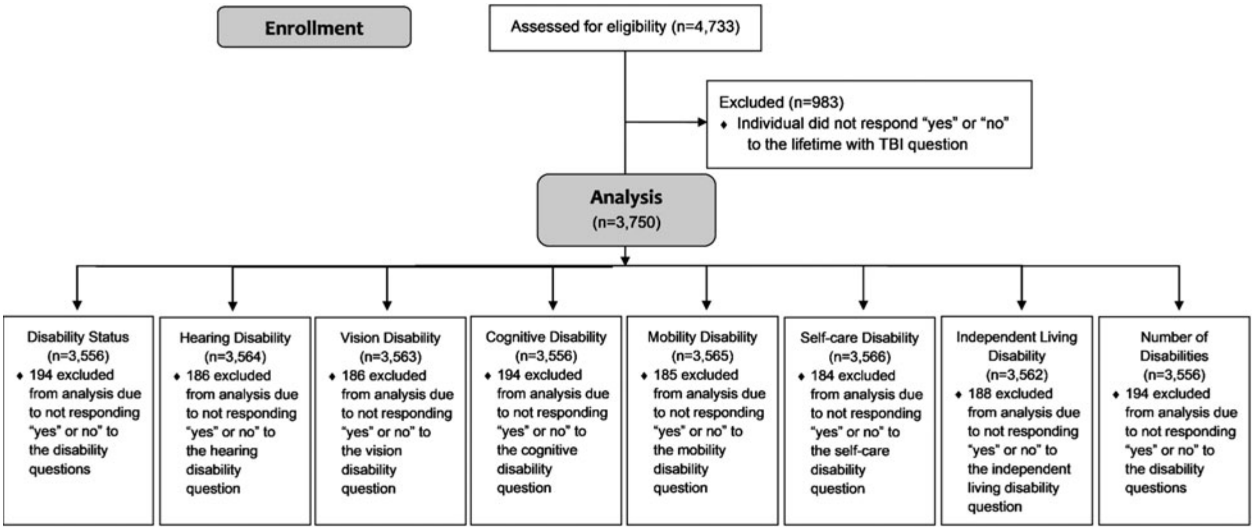


Figure 1. STROBE diagram of the statistical analysis of the respondents from the 2018 North Carolina BRFSS. TBI indicates traumatic brain injury.

BRFSS to estimate the prevalence of people living with a disability.[14] Current disability status was measured by combining these 6 questions from the core section of the 2018 North Carolina BRFSS. Before asking the questions on disability, the participants were told: "The following questions are about health problems or impairments you may have." The 6 questions on disability included the following: (1) "Some adults who are deaf or have serious difficulty hearing may or may not use equipment to communicate by phone. Are you deaf or do you have serious difficulty hearing?" (hearing disability); (2) "Are you blind or do you have serious difficulty seeing, even when wearing glasses?" (vision disability); (3) "Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making a decision?" (cognitive disability); (4) "Do you have serious difficulty walking or climbing stairs?" (mobility disability); (5) "Do you have difficulty dressing or bathing?" (self-care disability); and (6) "Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?" (independent living disability). Disability status was dichotomized as yes if respondents answered "yes" to any of these 6 questions and no if respondents answered "no" to all 6 disability questions. An analysis was conducted to determine the association between each type of current disability and history of TBI among all individuals in North Carolina and between veterans and nonveterans with a lifetime history of TBI. In addition, to assess the presence of multiple disabilities that may indicate the need for specialized care, the number of disabilities was calculated by summing across any yes responses to any of the 6 disabilities and categorized into a binary variable (1 or 2 or more).[10]

Veterans and nonveterans with a lifetime history of TBI

As mentioned, a secondary analysis was conducted to determine the association between each type of current disability and number of disabilities among veterans and nonveterans with TBI. The variable "veterans versus nonveterans with a lifetime history of TBI" was dichotomized as veterans if respondents answered "yes" to the veteran status and lifetime history of TBI question and nonveterans if respondents answered "no" to the veteran status and "yes" to the lifetime history of TBI question.

Statistical analysis

Descriptive and bivariate statistics were calculated to describe the demographic characteristics (sex, age, race/ethnicity, marital status, educational attainment, employment status, and federal poverty level[15]) and differences of North Carolina veteran and nonveteran adults (see Table 1). These statistics were limited to those who answered "yes" or "no" to the question on lifetime history of TBI. Bivariate statistics were calculated to determine which demographic characteristics and TBI variables ("lifetime history of TBI," "TBI severity," and "veterans vs nonveterans with lifetime history of TBI") were associated with the disability outcomes (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495). Demographics that were not the main predictors of interest (the TBI variables) and were associated with the disability outcomes were added as covariates in the final model. The bivariate statistics were also limited to those who answered the question on lifetime history of TBI and the respective disability question(s). To determine the

TABLE 1 *Demographic characteristics of adult respondents to the North Carolina Behavioral Risk Factor Surveillance System, 2018*[a]

	Total (all residents, *N* = 3570)		Veterans (*N* = 486)		Nonveterans (*N* = 3083)			
Characteristic	***N***	**Weighted percentage**	***N***	**Weighted percentage**	***N***	**Weighted percentage**	**Test statistic**	***P***
Sex							237.3	<.0001
Male	1609	46.3	422	87.0	1186	41.2		
Female	1960	53.7	64	13.0	1896	58.8		
Age							7.6	<.0001
Mean	3519	49.7	482	57.6	3037	48.7		
Race/ethnicity							18.5	<.001
Non-Hispanic White	2401	67.2	351	68.8	2050	67.0		
Non-Hispanic Black	695	21.4	103	26.4	592	20.8		
Non-Hispanic Other[b]	154	4.1	15	3.5	139	4.2		
Hispanic	269	7.3	11	1.3	258	8.0		
Veteran status							. . .	. . .
Yes	486	11.2	. . .	. . .	. . .	. . .		
No	3083	88.8	. . .	. . .	. . .	. . .		
Marital status							43.5	<.0001
Married	1715	52.2	287	66.0	1428	50.4		
Divorced/widowed/separated	1067	22.2	149	23.7	918	22.0		
Never married	659	21.9	41	8.9	618	23.6		
A member of an unmarried couple	116	3.7	8	1.4	108	3.9		
Educational attainment							43.7	<.0001
Less than high school	412	14.5	20	4.1	392	15.8		
Completed high school	874	25.6	108	23.1	766	25.9		
Some college	1069	34.4	183	47.5	886	32.8		
Bachelor's degree or higher	1208	25.5	175	25.3	1033	25.5		
Employment status							27.3	<.0001
Currently employed[c]	1754	55.2	160	41.6	1594	56.9		
Out of work	110	3.7	16	4.3	94	3.7		
Unable to find work	361	9.4	38	8.3	323	9.5		
Homemaker/student/retired	1326	31.7	270	45.8	1056	29.9		
Federal poverty level[d]							32.4	<.0001
<100%	377	11.6	16	3.8	361	12.6		
≥100% to <200%	770	19.8	102	20.0	668	19.8		
≥200%	1732	48.8	292	60.9	1440	47.3		
Unknown	691	19.7	76	15.3	614	20.3		
Lifetime TBI with loss of consciousness							16.1	<.0001
Yes	911	24.8	171	34.7	740	23.6		
No	2659	75.2	315	65.3	2343	76.4		

(*continues*)

TABLE 1 *Demographic characteristics of adult respondents to the North Carolina Behavioral Risk Factor Surveillance System, 2018*[a] (Continued)

Characteristic	Total (all residents, *N* = 3570)		Veterans (*N* = 486)		Nonveterans (*N* = 3083)		Test statistic	*P*
	N	Weighted percentage	*N*	Weighted percentage	*N*	Weighted percentage		
TBI severity[e]							1.3	.25
Mild (<30-min LOC)	698	85.2	128	81.4	570	85.9		
Moderate/severe (≥30-min LOC)	138	14.8	32	18.6	106	14.1		
Age of onset of first TBI with LOC[f]							0.3	.75
Mean	854	21.5	160	21.9	694	21.5		
Disability status							16.0	<.0001
Yes	1197	31.1	214	41.6	983	29.8		
No	2359	68.9	271	58.4	2088	70.2		
Hearing disability							42.4	<.0001
Yes	356	8.8	100	19.1	256	7.5		
No	3208	91.2	386	80.9	2822	92.5		
Vision disability							3.0	.08
Yes	236	5.9	44	8.4	192	5.6		
No	3327	94.1	441	91.6	2886	94.4		
Cognitive disability							3.2	.07
Yes	448	13.0	72	16.8	376	12.5		
No	3108	87.0	408	83.2	2699	87.5		
Mobility disability							6.3	.01
Yes	694	16.8	117	21.9	577	16.1		
No	2871	83.2	369	78.1	2501	83.9		
Self-care disability							1.2	.28
Yes	183	5.0	32	6.5	151	4.8		
No	3383	95.0	453	93.5	2929	95.2		
Independent living disability							0.4	.55
Yes	320	8.2	44	7.4	276	8.3		
No	3242	91.8	442	92.6	2799	91.7		
Number of disabilities[g]							0.3	.58
1	629	52.5	110	50.1	519	53.0		
≥2	568	47.5	104	49.9	464	47.0		

Abbreviations: LOC, loss of consciousness; TBI, traumatic brain injury.

[a] The sample includes only individuals those who responded to the lifetime TBI with LOC question (*N* = 3570).

[b] Includes those who answered that they were "non-Hispanic, Asian, American Indian and Alaska Native (AI/AN), or other."

[c] Includes those who are self-employed.

[d] Poverty categories are based on the ratio of the respondent's annual household income to the appropriate simplified 2017 federal poverty threshold (given family size: number of adults [1-14] in the household and number of children [≥0] in the household) defined by the US Census Bureau. This ratio is multiplied by 100 to be expressed as a percentage, and federal poverty thresholds were then used to categorize respondents into 4 FPL categories: (1) <100% of FPL, (2) ≥100% to <200% of FPL, (3) ≥200% of FPL, and (4) unknown.

[e] Total does not sum to 911 or 171 due to respondents who did not report the amount of time of LOC or refused to answer.

[f] Total does not sum to 911 or 171 due to respondents who did not know their age of first TBI or refused to answer.

[g] Includes those who reported at least 1 disability.

association between the TBI variables with disability outcomes, logistic regression with predicted marginals[16] was used to create models and adjusted for the demographic characteristics that were significant in the bivariate tests found in Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495. Furthermore, confounding was assessed using a change in parameter estimate of 10%[17,18] when the model was run with and without suspected confounders. Suspected confounders were variables that were associated with the main predictors of interest (the TBI variables). The final multivariable binomial logistic regression models were formed from variables that either had a significant association ($P \leq .05$) with the outcome or resulted in at least a 10% change of the parameter estimate (see Figure 2). Associations are presented as adjusted prevalence ratios (APRs). In addition, multicollinearity between the demographic characteristics was assessed for each multivariable binomial logistic regression model. Separate analyses were conducted for each of the disability outcome variables (disability status, disability type, and number of disabilities). The significance level of the tests was set at $\alpha = .05$. All analyses were performed in SAS 9.4 (SAS Institute, Cary, North Carolina) and SUDAAN version 11.0.0 (Research Triangle Institute, Research Triangle Park, Cary, North Carolina), taking the complex survey design into account and incorporating the design weight, strata, and the primary sampling unit.

RESULTS

Of the 4686 respondents in the survey, 3570 (76%) answered the lifetime history of TBI question. Respondents who did not answer this question compared with those who did were different on all demographic characteristics (except for marital status), as well as the reported outcome disability variables (data not shown). A higher percentage of those who answered were female, older,

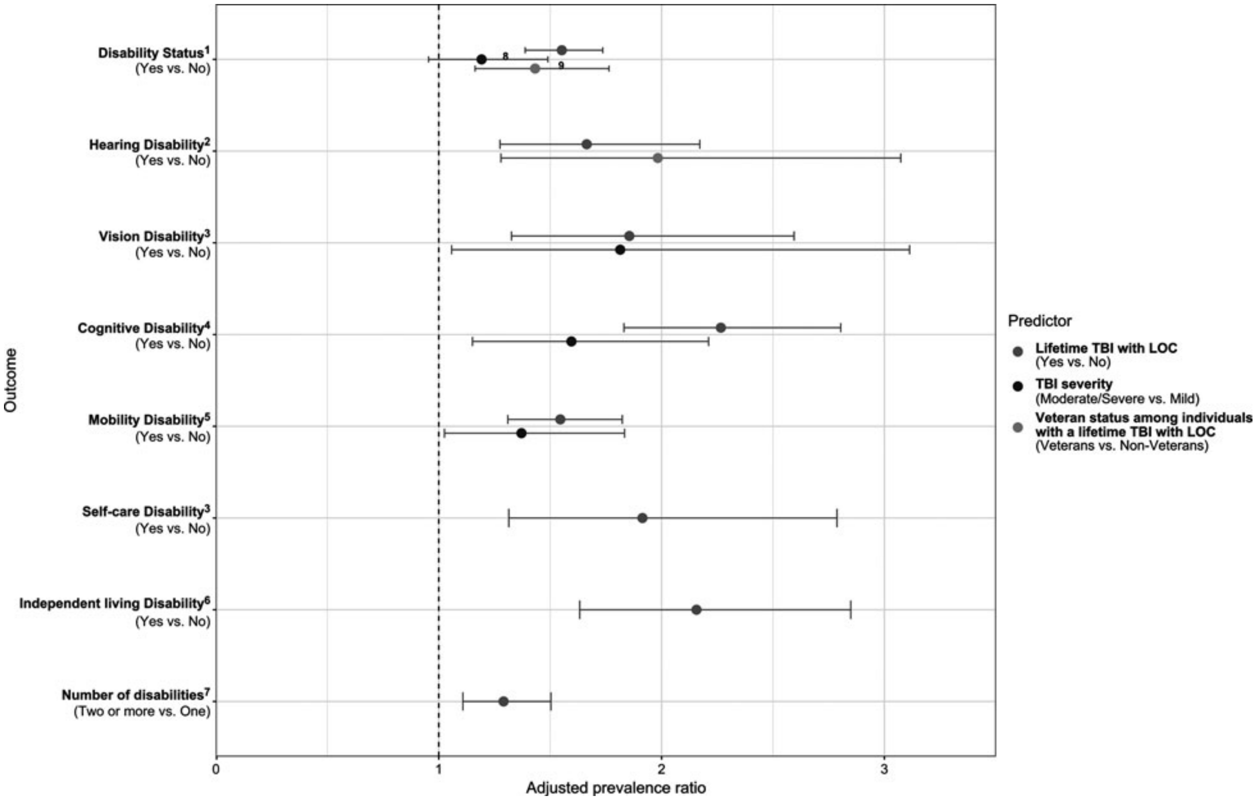


Figure 2. Adjusted prevalence ratio and 95% CI for the relationship between history of traumatic brain injury with loss of consciousness and living with a current disability–North Carolina Behavioral Risk Factor Surveillance System, 2018. [a]Outcome adjusted for age, veteran status, marital status, education, employment, and federal poverty level. [b]Outcome adjusted for age, veteran status, education, and employment. [c]Outcome adjusted for age, marital status, education, employment, and federal poverty level. [d]Outcome adjusted for marital status, education, employment, and federal poverty level. [e]Outcome adjusted for sex, age, veteran status, marital status, education, employment, and federal poverty level. [f]Outcome adjusted for sex, age, marital status, education, employment, and federal poverty level. [g]Outcome adjusted for age, race/ethnicity, marital status, employment, and federal poverty level. [h]Outcome additionally adjusted for race/ethnicity due to the variable being a confounder that resulted in at least a 10% change of the parameter estimate. [i]Outcome additionally adjusted for sex due to the variable being a confounder that resulted in at least a 10% change of the parameter estimate. LOC indicates loss of consciousness; TBI, traumatic brain injury.

had some college education, were out of work or unable to find work or were a homemaker or student or retired, less than 200% or less of the federal poverty-level income, were non-Hispanic White, nonveterans, had a higher percentage of any disability and disabilities in cognition, hearing, independent living, mobility, self-care, and vision, and had a greater number of disabilities.

Demographic characteristics among veteran and nonveteran residents in North Carolina

There were significant demographic differences between veterans and nonveterans. For example, a higher percentage of veterans than nonveterans were male, non-Hispanic Black, married, had some college, were homemakers/students/retired, and had an income that was 200% of the federal poverty level and higher. The mean age of veterans was also significantly higher than the mean age of nonveterans (see Table). Among veterans residing in North Carolina, approximately 34.7% reported having a lifetime history of TBI compared with 23.6% of nonveterans. Approximately 41.6% of veterans and 29.8% of nonveterans in North Carolina self-reported living with 1 or more disabilities at the time the survey was administered. Among veterans, the most common type of disability was mobility- (21.9%), followed by hearing- (19.1%) and cognitive- (16.8%) related disabilities. However, for nonveterans, the most common disabilities included mobility (16.1%), followed by cognitive- (12.5%) and independent living– (8.3%) related disabilities. Among those reporting a disability, approximately the same percentage of veterans reported living with 1 (50.1%) as with 2 or more (49.9%) current disabilities. Nonveterans with a disability reported similar percentages (1 disability = 53.0%; 2 or more disabilities = 47.0%).

Association between lifetime history of TBI and living with a current disability among residents of North Carolina

The prevalence of disability among those with a lifetime history of TBI was 42.6% while the prevalence of disability among those who did not have a lifetime history of TBI was 27.3% (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495). After adjustment for demographic and/or confounding factors that were significantly associated with having a disability (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495), lifetime history of TBI among all residents of North Carolina was associated with increased risk of having any disability (APR = 1.6; 95% confidence interval [CI], 1.4-1.7) (see Figure 2). Among all residents of North Carolina who had a lifetime history of TBI, there was an increased risk of having a disability related to hearing (APR = 1.7; 95% CI, 1.3-2.2), vision (APR = 1.9; 95% CI, 1.3-2.6), cognition (APR = 2.3; 95% CI, 1.8-2.8), mobility (APR = 1.5; 95% CI, 1.3-1.8), self-care (APR = 1.9; 95% CI, 1.3-2.8), and independent living (APR = 2.2; 95% CI, 1.6-2.9) compared with residents who did not have a lifetime history of TBI. In addition, among all residents of North Carolina, having a lifetime history of TBI was also associated with a greater number of disabilities (2 or more vs 1: APR = 1.3; 95% CI, 1.1-1.5) compared with those without a lifetime history of TBI.

After adjustment for demographic and/or confounding factors that were significantly associated with having a disability (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495), TBI severity was not associated with overall disability status (APR = 1.2; 95% CI, 0.95-1.5). However, having a lifetime history of a moderate/severe TBI was associated with increased risk of having a disability related to vision (APR = 1.8; 95% CI, 1.1-3.1), cognition (APR = 1.6; 95% CI, 1.2-2.2), and mobility (APR = 1.4; 95% CI, 1.03-1.8) compared with individuals having a lifetime history of mild TBI (see Figure 2). Neither the bivariate association between TBI severity and having a disability related to hearing, self-care, and independent living nor number of disabilities was statistically significant (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495); thus, no multivariable modeling was conducted for these variables.

Associations between lifetime history of TBI and veteran status with current disability

The prevalence of disability among veterans with a lifetime history of TBI was 52.2% while the prevalence of disability among nonveterans with a lifetime history of TBI was 40.8% (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495). After adjustment for demographic and/or confounding factors that were significantly associated with having a disability (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495), being a veteran with a lifetime history of TBI in North Carolina was associated with increased risk of having any disability (APR = 1.4; 95% CI, 1.2-1.8) and a disability related to hearing (APR = 2.0; 95% CI, 1.3-3.1) (see Figure 2) as compared with nonveterans with a lifetime history of TBI. The bivariate association between lifetime history of TBI between veterans and nonveterans in North Carolina and with having a disability related to vision, cognition, mobility, self-care, and independent living was not statistically significant (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A495). Thus, no multivariable modeling was conducted for these variables.

DISCUSSION

Findings from this article suggest that approximately one-third of veterans and a quarter of nonveterans residing in North Carolina have sustained a TBI in their lifetime. Compared with nonveterans, veterans who reported a lifetime history of TBI had an increased risk of reporting a current disability. While it is likely that many of these individuals have a disability that was not due to their TBI, the significant association between having a lifetime history of TBI and living with a current disability identifies a group that may warrant attention. In-depth retrospective studies could explore this relationship and inform the development of targeted interventions. However, to our knowledge no current data system includes this information. Until a national surveillance system to capture TBI data is created, estimating the true burden of disability that resulted from a TBI in the United States will be an ongoing challenge.

The most common types of disabilities found in this study were mobility, cognitive, and hearing. Disabilities of many types–including the ones listed previously–are a common consequence of TBI.[1] Previous research has found that the most common type of disability experienced by TBI survivors is cognitive in nature, particularly related to memory loss or difficulty forming new memories.[1] Potentially related to the disabilities that an individual experiences, sustaining a TBI is associated with increased incidence of mental illness, challenges with social integration, difficulties with employment, activity limitations, and lower self-reported quality of life.[1,19–22] Expanded access to rehabilitative services, including mental health services and job training programs, may be beneficial to support individuals living with a TBI and improve their well-being.[1]

According to the US Department of Veterans Affairs, North Carolina ranks eighth among US states with the highest population of veterans.[23] Approximately half of the veterans in the state who self-reported a lifetime history of TBI also reported at least 1 current disability. Previous research has found that service members who sustain a TBI during combat may have more detrimental sequelae than service members who did not sustain a TBI during combat.[24] This may be associated with the circumstances in which they sustained their injuries (eg, increased likelihood of polytrauma) and potential for comorbid conditions (eg, PTSD).[2,24] While the exposure to combat increases the risk for TBI, such as those from a blast-related injury,[9] approximately 80% of TBIs among service members and veterans occur in nondeployed settings (eg, motor vehicle crashes).[2] There is some evidence to suggest that veterans may have difficulty accessing healthcare or experience long wait times for care at federally funded facilities (especially among those living in rural areas).[25] Moreover, research suggests that veterans have an increased risk for psychological comorbidities (eg, PTSD, depression),[26] have some unique factors that may contribute to high rates of suicide,[27] and are more likely to experience postconcussive symptoms than civilians.[28] In addition, as noted in this study, veterans are more likely than nonveterans to have a hearing disability.[29] Taken together, these findings point to the distinctive needs that veterans face for their overall health and when recovering from a TBI. They also highlight the importance of efforts to improve rehabilitation services for veterans with TBI complicated by psychological conditions and inclusive of interventions to facilitate the transition from military to civilian life.[2]

For people with a lifetime history of TBI, the higher rate of disability as compared with the general population in North Carolina, often in more than 1 functional domain, suggests the need for a collaborative care approach among healthcare (eg, primary care providers, specialists, rehabilitative service providers) and public health professionals. For example, persons living with a TBI and a mobility disability may experience environmental and transportation barriers accessing healthcare services, whereas those with a TBI and a cognitive disability may have difficulty understanding or adhering to self-care practices. Furthermore, people living with a TBI, with or without disability, may struggle with maintaining a healthy lifestyle.[1] Emotional well-being (eg, social connectedness through employment, social role within the household) might prevent or delay secondary conditions for which they are at increased risk compared with patients without disabilities (eg, depression, anxiety, chronic obstructive pulmonary disease, dementia, seizure).[30] Compared with people without a history of TBI, people with a history of mild, moderate, or severe TBI and who are receiving care have more physician visits, which provide an opportunity for lifestyle counseling.[30] Building connections between the healthcare community and public health professionals may help address the complex health, social, and economic needs of people living with a TBI.[31] Furthermore, public health interventions tailored to improve access to healthcare services, social connections, and employment need to be adapted and evaluated for people living with a TBI and disabilities in a specific functional domain or multiple domains.[31]

Limitations

There are several limitations to this study. First, because the data in the BRFSS are retrospective and cross-sectional, it is not possible to determine temporality and causality between lifetime history of TBI and living with a current disability. While sustaining a TBI of any severity increases the risk for disability, the reverse may also be true.[32] Longitudinal studies or direct measurement of TBI-related disability may further elucidate this relationship. Related, it was not possible to measure whether the reported disability was TBI-related. It is likely that many of the reported disabilities were not due to the TBI that was sustained. Second, BRFSS data are based on self-report and subject to recall bias. However, the data do provide results that can be used to inform larger, more robust studies about individuals with TBI and disability. Third, the BRFSS telephone survey might underestimate the prevalence of disability because it is conducted among noninstitutionalized adults and those with more severe disabilities may not answer the survey or may live in institutional settings or group homes. Fourth, there was a high percentage of missing data for the question on lifetime history of TBI (ie, 24% of respondents did not answer the question, $N = 1116$). This was due to partial completion of the survey (ie, respondents who ended the interview before the TBI optional module). Furthermore, respondents who did not answer this question compared with those who did were different on all demographic characteristics (except for marital status), as well as the reported outcome disability variables. It is therefore possible that the findings from this study are not generalizable to those groups that were less likely to answer the TBI questions (eg, males and younger people), and it is also possible that the prevalence of disability is under- or overestimated. In addition, since the data are only from North Carolina, these findings are generalizable only to individuals in North Caroline and not to the larger BRFSS sample. Fifth, the inclusion of LOC in the lifetime TBI question likely biased toward more severe brain injuries by inquiring only about that single symptom. Studies suggest that only about 5.7% to 12%[33–35] of people who sustain a TBI lose consciousness. Thus, this study likely underestimates the prevalence of TBI in North Carolina, and the association between TBIs without LOC and disability may be different. Consequently, it is not possible to know whether these results are generalizable to those with potentially less severe forms of TBI. Moreover, some individuals may not recall whether they lost consciousness. This may be especially true among those who sustained a TBI many years ago or when they were a child and those who did not seek medical care.

CONCLUSION

This study demonstrates that there is a significant association between having a history of TBI and living with a current disability among residents in North Carolina, especially among veterans. In-depth retrospective studies on lifetime history of TBI and subsequent disability may be beneficial to explore this relationship further and inform the development of targeted interventions, such as those that improve mobility. Furthermore, broader use of evidence-based prevention strategies, such as those that mitigate falls among older adults and motor vehicle crash–related injuries, may help reduce the burden of this injury.

REFERENCES

1. Centers for Disease Control and Prevention. Report to congress on traumatic brain injury in the United States: epidemiology and rehabilitation. National Center for Injury Prevention and Control; Division of Unintentional Injury Prevention. Published September 21, 2019. Accessed September 21, 2019. https://www.cdc.gov/traumaticbraininjury/pdf/tbi_report_to_congress_epi_and_rehab-a.pdf
2. Centers for Disease Control and Prevention, National Institute of Health, Department of Defense, Panel. VAL. *Report to congress on traumatic brain injury in the United States: understanding the public health problem among current and former military personnel.* Published 2013. Accessed September 7, 2021. https://www.cdc.gov/traumaticbraininjury/pdf/Report_to_Congress_on_Traumatic_Brain_Injury_2013-a.pdf
3. Loignon A, Ouellet M-C, Belleville G. A Systematic review and meta-analysis on PTSD following TBI among military/veteran and civilian populations. *J Head Trauma Rehabil.* 2020;35(1):E21–E35. doi:10.1097/htr.0000000000000514
4. Merz ZC, Roskos PT, Gfeller JD, Bucholz RD. Impact of psychiatric symptomatology on neuropsychological assessment performance in persons with TBI: a comparison of OEF/OIF veteran and civilian samples. *Brain Inj.* 2017;31(11):1422–1428. doi:10.1080/02699052.2017.1339124
5. Gfeller JD, Roskos PT. A comparison of insufficient effort rates, neuropsychological functioning, and neuropsychiatric symptom reporting in military veterans and civilians with chronic traumatic brain injury. *Behav Sci Law.* 2013;31(6):833–849. doi:10.1002/bsl.2084
6. Selassie AW, Zaloshnja E, Langlois JA, Miller T, Jones P, Steiner C. Incidence of long-term disability following traumatic brain injury hospitalization, United States, 2003. *J Head Trauma Rehabil.* 2008; 23(2):123–131. doi:10.1097/01.HTR.0000314531.30401.39
7. Zaloshnja E, Miller T, Langlois JA, Selassie AW. Prevalence of long-term disability from traumatic brain injury in the civilian population of the United States, 2005. *J Head Trauma Rehabil.* 2008; 23(6):394–400. doi:10.1097/01.HTR.0000341435.52004.ac
8. Centers for Disease Control and Prevention. *Surveillance Report of Traumatic Brain Injury-related Emergency Department Visits, Hospitalizations, and Deaths—United States, 2014.* National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, US Department of Health & Human Services; 2019.

9. Lindquist LK, Love HC, Elbogen EB. Traumatic brain injury in Iraq and Afghanistan veterans: new results from a national random sample study. *J Neuropsychiatry Clin Neurosci*. Summer 2017;29(3): 254–259. doi:10.1176/appi.neuropsych.16050100
10. Yi H, Corrigan JD, Singichetti B, et al. Lifetime history of traumatic brain injury and current disability among Ohio adults. *J Head Trauma Rehabil*. 2018;33(4):E24–E32. doi:10.1097/htr.0000000000000352
11. North Carolina State Center for Health Statistics DoPH. *North Carolina Behavioral Risk Factor Surveillance System survey data*. North Carolina State Center for Health Statistics; 2017.
12. *Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System: comparability of data BRFSS 2017*. Published 2017. Accessed August 30, 2021. https://www.cdc.gov/brfss/annual_data/2017/pdf/compare-2017-508.pdf
13. Corrigan JD, Yang J, Singichetti B, Manchester K, Bogner J. Lifetime prevalence of traumatic brain injury with loss of consciousness. *Inj Prev*. 2018;24(6):396–404. doi:10.1136/injuryprev-2017-042371
14. Stevens AC, Courtney-Long EA, Okoro CA, Carroll DD. Comparison of 2 disability measures, Behavioral Risk Factor Surveillance System, 2013. *Prev Chronic Dis*. 2016;13:E106. doi:10.5888/pcd13.160080
15. Services USDoHaH. Annual update of the HHS poverty guidelines. Published March 17, 2021. Accessed November, 2020. https://www.peoplekeep.com/blog/2017-federal-poverty-level-guidelines
16. Bieler GS, Brown GG, Williams RL, Brogan DJ. Estimating model-adjusted risks, risk differences, and risk ratios from complex survey data. *Am J Epidemiol*. 2010;171(5):618–623. doi:10.1093/aje/kwp440
17. Mickey RM, Greenland S. The impact of confounder selection criteria on effect estimation. *Am J Epidemiol*. 1989;129(1):125–137. doi:10.1093/oxfordjournals.aje.a115101
18. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. *Am J Epidemiol*. 1993;138(11):923–936. doi:10.1093/oxfordjournals.aje.a116813
19. Andelic N, Howe EI, Hellstrøm T, et al. Disability and quality of life 20 years after traumatic brain injury. *Brain Behav*. 2018;8(7): e01018. doi:10.1002/brb3.1018
20. Ponsford JL, Spitz G. Stability of employment over the first 3 years following traumatic brain injury. *J Head Trauma Rehabil*. 2015; 30(3):E1–11. doi:10.1097/htr.0000000000000033
21. Andelic N, Sigurdardottir S, Schanke AK, Sandvik L, Sveen U, Roe C. Disability, physical health and mental health 1 year after traumatic brain injury. *Disabil Rehabil*. 2010;32(13):1122–1131. doi:10.3109/09638280903410722
22. Rivara FP, Koepsell TD, Wang J, et al. Disability 3, 12, and 24 months after traumatic brain injury among children and adolescents. *Pediatrics*. 2011;128(5):e1129–e1138. doi:10.1542/peds.2011-0840
23. National Center for Veterans Analysis and Statistics. US Department of Veterans Affairs. Published April 14, 2021. Accessed September 24, 2020. https://www.va.gov/vetdata/Veteran_Population.asp
24. Mac Donald CL, Johnson AM, Wierzechowski L, et al. Outcome trends after US military concussive traumatic brain injury. *J Neurotrauma*. 2017;34(14):2206–2219. doi:10.1089/neu.2016.4434
25. Daley J. Ensuring timely access to quality care for US veterans. *JAMA*. 2018;319(5):439–440. doi:10.1001/jama.2017.20743
26. Bryant R. Post-traumatic stress disorder vs traumatic brain injury. *Dialogues Clin Neurosci*. 2011;13(3):251–262. doi:10.31887/DCNS.2011.13.2/rbryant
27. Wood DS, Wood BM, Watson A, Sheffield D, Hauter H. Veteran suicide risk factors: a national sample of nonveteran and veteran men who died by suicide. *Health Soc Work*. 2020;45(1):23–30. doi:10.1093/hsw/hlz037
28. Reid MW, Velez CS. Discriminating military and civilian traumatic brain injuries. *Mol Cell Neurosci*. 2015;66(pt B):123–128. doi:10.1016/j.mcn.2015.03.014
29. Lucas JW, Zelaya CE. Hearing difficulty, vision trouble, and balance problems among male veterans and nonveterans. *Natl Health Stat Report*. 2020;(142):1–8.
30. McDermott S, Moran R, Platt T, Isaac T, Wood H, Dasari S. Risk for onset of health conditions among community-living adults with spinal cord and traumatic brain injuries. *Prim Health Care Res Dev*. 2007;8(1):36–43. doi:10.1017/S1463423607000059
31. Stephens JA, Williamson KN, Berryhill ME. Cognitive rehabilitation after traumatic brain injury: a reference for occupational therapists. *OTJR (Thorofare N J)*. 2015;35(1):5–22. doi:10.1177/1539449214561765
32. Sinclair SA, Xiang H. Injuries among US children with different types of disabilities. *Am J Public Health*. 2008;98(8):1510–1516. doi:10.2105/AJPH.2006.097097
33. Frost RB, Farrer TJ, Primosch M, Hedges DW. Prevalence of traumatic brain injury in the general adult population: a meta-analysis. *Neuroepidemiology*. 2013;40(3):154–159. doi:10.1159/000343275
34. Silver JM, Kramer R, Greenwald S, Weissman M. The association between head injuries and psychiatric disorders: findings from the New Haven NIMH Epidemiologic Catchment Area Study. *Brain Inj*. 2001;15(11):935–945. doi:10.1080/02699050110065295
35. Anstey KJ, Butterworth P, Jorm AF, Christensen H, Rodgers B, Windsor TD. A population survey found an association between self-reports of traumatic brain injury and increased psychiatric symptoms. *J Clin Epidemiol*. 2004;57(11):1202–1209. doi:10.1016/j.jclinepi.2003.11.011

Rehabilitation Psychology

© 2021 American Psychological Association
ISSN: 0090-5550

2021, Vol. 66, No. 4, 345–355
https://doi.org/10.1037/rep0000405

Comparative Effectiveness of a Brief Intervention for Alcohol Misuse Following Traumatic Brain Injury: A Randomized Controlled Trial

Jennifer Bogner[1], John D. Corrigan[1], Juan Peng[2], Chelsea Kane[1], and Kathryn Coxe[3]
[1] Department of Physical Medicine and Rehabilitation, Division of Rehabilitation Psychology, College of Medicine, Ohio State University
[2] Center for Biostatistics, College of Medicine, Ohio State University
[3] College of Social Work, Ohio State University

Purpose/Objective: Compare the effects of an adapted Screening, Education, and Brief Intervention (Adapted SBI) for alcohol misuse following traumatic brain injury (TBI) to a Screening and Education with Attention Control (SEA) condition. ***Study Design:*** A single-masked, parallel group, randomized controlled trial was conducted with 58 participants who were 18 and older, sustained a TBI requiring inpatient rehabilitation, had a history of alcohol misuse, were English-speaking, cleared posttraumatic amnesia, were free of language impairments precluding participation in the intervention, and who provided informed consent. Outcomes were collected at 3, 6, and 12 months postdischarge. The primary outcome was drinks per week at 12 months postdischarge. ***Results:*** Participants in both conditions reduced alcohol use following their injury. The number of drinks per week at 12 months did not differ between the treatment conditions; the number of drinks consumed across the entire sample was very low (median = 0). A lower percentage of participants in the Adapted SBI condition resumed alcohol use by 12 months postdischarge (32% vs. 62% in the SEA condition, $p < .05$). No significant differences were found on other outcomes (binging, facts recalled about the negative effects of alcohol, drug use). The inclusion of a booster session did not appear to alter the intervention effects. The interventions did not impact other healthy behaviors, however healthy eating and stress management practices were associated with abstaining from alcohol use at the 12-month follow-up. ***Conclusions/Implications:*** While alcohol misuse generally declines postinjury, by 12 months postdischarge many individuals resume alcohol use. Adapted SBI may slow the resumption of alcohol use.

Impact and Implications

One-third to one-half of individuals who have sustained a moderate-severe traumatic brain injury (TBI) have a history of alcohol misuse and are at risk for resumption of hazardous alcohol use postinjury. Screening and Brief Interventions (SBI) are the standard of care for preventing the resumption of alcohol misuse following traumatic injuries, however, prior studies indicated limited effectiveness when used with persons with TBI. While the current study did not find an effect for the primary outcome (amount of alcohol consumed each week), the study demonstrated that an Adapted SBI accommodated to cognitive problems can be effective in decreasing the likelihood that an individual will resume any alcohol use during the year following inpatient rehabilitation for TBI.

Keywords: alcohol abuse, substance abuse, traumatic brain injury, secondary prevention, intervention

Supplemental materials: https://doi.org/10.1037/rep0000405.supp

Introduction

Misuse of alcohol and other drugs is among the top three factors accounting for disability-adjusted life years in the U.S. general population (The US Burden of Disease Collaborators, 2018). Approximately one third of visits to trauma centers for any injury or disorder are alcohol-related (MacLeod & Hungerford, 2011), and

---

Jennifer Bogner https://orcid.org/0000-0003-4675-7466
John D. Corrigan https://orcid.org/0000-0002-7591-5622
Kathryn Coxe https://orcid.org/0000-0002-7813-1081

This work was funded via Grant H133A120086 from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR, formerly a Center in the U.S. Department of Education, currently in the Administration for Community Living [ACL]). The contents of this publication do not necessarily represent the policy of NIDILRR, ACL, US Department of Health and Human Services (HHS), and you should not assume endorsement by the Federal Government.

We would like to acknowledge the important contributions of April Smith, Elizabeth Windisch, Jan Dickerson, Michael Mahaffey, as well as Frantz Moise, Jessica McDonald, and Reneh Karamians.

Correspondence concerning this article should be addressed to Jennifer Bogner, PhD, Department of Physical Medicine and Rehabilitation, Division of Rehabilitation Psychology, College of Medicine, Ohio State University, 2145 Dodd Hall, 480 Medical Center Drive, Columbus, OH 43210, United States. Email: Bogner.1@osu.edu

one third to one half of persons who have sustained a moderate-severe TBI have a history of alcohol misuse or illicit drug use (Corrigan, 1995; Parry-Jones et al., 2006). While alcohol and other drug misuse initially declines following a TBI, use often resumes and increases with time (Adams et al., 2012; Beaulieu-Bonneau et al., 2018; Ponsford et al., 2007; Weil et al., 2016). Persons with a history of alcohol misuse prior to a TBI are at the greatest risk for alcohol misuse following injury, however sustaining a TBI may also increase risk of developing a new alcohol use disorder, particularly if the injury is sustained in childhood (Kennedy et al., 2017; Kennedy et al., 2017; McKinlay et al., 2014; Timonen et al., 2002). Comorbid TBI and alcohol misuse has been associated with poorer global outcomes (Singh et al., 2019), and specifically increased risk for other psychiatric disorders (Hart et al., 2014; Unsworth & Mathias, 2017), suicide attempt (Chang et al., 2019), reinjury (Bannon et al., 2021), more impaired lower cognitive and executive functioning (Ponsford et al., 2013), and hospital readmission (Marcoux et al., 2017).

Following an injury leading to Emergency Department care or hospitalization, patients with a history of hazardous alcohol use may experience a ‘teachable moment’, when they are more receptive to learning about the risks associated with their use and to considering behavior change (Lau et al., 2010; Minugh et al., 1997; Williams et al., 2005). Screening and Brief Intervention (SBI), also called Screening, Brief Intervention and Referral to Treatment (SBIRT), was developed with the intent of capitalizing on teachable moments in the emergency department, trauma service, and primary care settings. SBI is the standard of care for addressing excessive alcohol and other drug use among patients seen in health care centers (Joint Commission, 2007; Makdissi & Stewart, 2013; Saitz, 2010b). Multiple systematic reviews have demonstrated that SBI reduces alcohol misuse and alcohol-related complications (Barata et al., 2017; Kaner et al., 2018; McQueen et al., 2011; O'Connor et al., 2018; O'Donnell et al., 2014).

Less is known about SBI outcomes with individuals with TBI. A systematic rereview of the efficacy and effectiveness studies for SBI in emergency departments and trauma units indicated that studies excluded any patients who were not completely oriented and free of confusion because they were not considered capable of providing informed consent (Corrigan et al., 2010). Patients with more severe TBI are highly unlikely to be oriented while still in acute care and were therefore likely to be excluded from participation in the prior SBI studies. Moreover, evidence suggests that even patients with TBI of milder severity are less likely to benefit from SBI when compared to persons without TBI (Zatzick et al., 2014).

Given the adverse impact of misuse of alcohol as well as other drugs on TBI outcomes, it is critical to identify interventions which can effectively reduce substance misuse. Three randomized controlled trials have evaluated a multimedia (video and booklet) educational intervention that included eight messages illustrating the negative consequences of alcohol or drug use following TBI (Corrigan, 2004, 2005; Sander et al., 2012; Tweedly et al., 2012). As is typical with SBI, in two of the studies, the educational intervention was offered with a brief motivational interview: a client-centered, collaborative, goal-oriented method for addressing ambivalence and for guiding motivation to change behavior (Miller & Rollnick, 2013; Sander et al., 2012; Tweedly et al., 2012). In combination, the findings from these studies suggested that the multimedia educational component of the interventions had a positive impact on knowledge and beliefs about alcohol misuse, but more limited effects on actual alcohol use. The motivational interview component did not add to the effects observed from the educational intervention alone (Bogner & Corrigan, 2013).

The dearth of significant effects of SBI on behavior change among persons with TBI suggests a need for modifications to the intervention as well as a reconsideration of the study methodology. First, problems with lower cognitive and executive functioning could potentially impact the ability to benefit from the SBI. Accommodations for cognitive problems may therefore improve the effectiveness of SBI. Second, emerging evidence suggests that framing substance misuse interventions within a health and wellness context may increase effectiveness with adolescents and adults in the general population, and deserves evaluation with persons with TBI as well (Cabé et al., 2021; Dai et al., 2020; Simonton et al., 2018). Third, in regard to study methodology, a longer timeframe for follow-up may improve the ability to detect effects since many individuals initially refrain from alcohol use but return to higher consumption levels as months postinjury increase. In contrast to studies with shorter time frames (Corrigan, 2005; Sander et al., 2012). Tweedly et al. (2012) followed participants at one year after injury, and found some participants in the control group had resumed drinking by the end of that year. Though their sample did not have a heavy drinking history prior to the injury and those that resumed were not drinking at hazardous levels, a moderate non-significant effect of the educational intervention was discernible.

The current study was designed to correct the limitations of the previous studies. We developed an Adapted SBI that included the multimedia educational intervention and an adapted motivational interview with individualized cognitive accommodations, a written “Brain Health Plan,” and a booster session. The efficacy of Adapted SBI was compared against the multimedia education previously tested (called Screening and Education with Attention Control [SEA]). Both interventions were presented within a health and wellness theme, however the Adapted SBI went a step further with the Brain Health Plan that was used to establish goals related to healthy behaviors and the reduction of substance use. Given that the multimedia psychoeducational materials appear to have some limited efficacy on their own (Corrigan, 2004, 2005; Sander et al., 2012; Tweedly 2012), we anticipated that both groups would show some reduction in alcohol misuse. Our primary hypothesis, however, was that the Adapted SBI would be more efficacious than the SEA control condition on reducing alcohol consumption in the year following the index TBI. The primary outcome was the amount of alcohol consumed during a typical week at one-year postinjury. Secondarily, we also evaluated effects on alcohol use as a dichotomous variable; that is, whether the participant completely abstained from alcohol use or not. We anticipated that the differences between the two groups would not emerge immediately but would increase as the year passed. Secondary outcomes included binge use (defined here as 5 or more drinks at a sitting) and the number of facts about the negative effects of alcohol use that were recalled. We also explored the effects of the intervention on the use of illicit drugs.

Method

Prior to data collection, approval for human subjects research was obtained from the host facility’s Institutional Review Board.

A randomized controlled trial was used to evaluate the efficacy of Adapted SBI relative to a SEA control (Clinicaltrials.gov# NCT02129361). Following completion of the baseline assessment, participants were randomly assigned to Adapted SBI or SEA control using block randomization. The random allocation sequence and blocking method were concealed from the enrollment staff, interventionists, and staff conducting outcomes assessments. The allocations were stratified by interventionist and were pregenerated in a table using a random-number generator, with each assignment concealed, and only revealed to the interventionist following the baseline assessment. Data on outcomes were collected by phone at 3, 6, and 12 months after rehabilitation discharge by research assistants masked to group assignment. A probe conducted with the last eleven interviews conducted at 12 month follow-up indicated that the masking was successful: the staff conducting the interviews correctly ascertained only 3 of the 11 assignments.

Participants

Participants included persons who sustained a TBI followed by disability of sufficient severity to warrant admission to an inpatient rehabilitation facility, which was located within a Midwestern U. S. academic medical center. Participants must have (a) sustained a TBI defined as damage to the brain tissue caused by an external force, as evidenced by loss of consciousness, posttraumatic amnesia, skull fracture, or objective neurological findings; (b) a history of alcohol misuse within the year prior to injury (may also have used other drugs, but not necessary for inclusion); (c) been at least 18 years old and English-speaking; (d) cleared posttraumatic amnesia and been free of language impairments that would preclude participation in the intervention; and (e) been able and willing to provide informed consent. We operationalized alcohol misuse as meeting one of the following criteria: (a) >7 drinks/week for all women and for men over the age of 65; (b) >14 drinks/week for men ≤ 65 years old, (c) 4 or more drinks at least one occasion per month for women and 5 or more drinks on an occasion for men. The original power analysis called for 35 participants per group, however it was not possible to achieve this sample size in the time period allotted for this study.

Interventions

Alcohol and other drug screening were completed during the baseline assessment, prior to randomization into the intervention groups. Both the Adapted SBI and SEA conditions were provided by the same interventionists, who were mental health professionals who received training on the interventions used in the current study. The initial session took approximately 25–30 minutes and occurred prior to inpatient discharge. Booster sessions lasted about 10–15 minutes and occurred one month postdischarge by telephone. Both conditions were introduced to participants as an intervention to promote health and optimal TBI recovery. All participants received a fact sheet containing recommendations for healthy behaviors from the Centers for Disease Control and Prevention. During the initial session, both groups viewed a video illustrating eight facts regarding the negative effects of substance misuse after TBI (Olson-Madden et al., 2012), with an accompanying information sheet for participants to take home to review or share with others. The standard of care on the rehabilitation unit was maintained for both conditions, which included referral for ongoing treatment for those patients with a history of substance use disorder. See Table 1 for the components of the intervention conditions.

Adapted SBI

Following the video, the interventionist began a brief motivational interview which targeted healthy behaviors and alcohol misuse, including other drugs, as applicable. The motivational interview was left unstructured, allowing the interventionists to call upon the general principles of motivational interviewing without being restricted to a script. A readiness ruler was used to assess the individual's readiness to change, with readiness determining the direction of the remaining interview. The interventionists' goals were to elicit and reinforce verbalizations associated with changing behavior, avoid verbalizations associated with sustaining alcohol use behaviors, and to assist the participant in developing a Brain Health Plan that included three goal activities that they would pursue to support progress toward change in substance use and healthy behaviors more generally. In addition, accommodations and strategies for assisting the participant with recalling and implementing their plan for change were discussed with the participant, drawing upon previous strategies the participant may have used as well as the following options: (a) use phone to cue recall (e.g., applications, calendar, text message); (b) put reminders around home, key places and/or in calendar/planner; and/or (c) wear a bracelet or another item that will cue recall. Interventionists were free to choose from strategies appropriate to the individual's readiness to change, as long as they follow the basic principles of motivational interviewing: a) understand the client's perspective (express empathy); b) increase confidence that they can successfully change (support self-efficacy); c) avoid argumentative

Table 1
Components of Intervention Conditions

Adapted Screening, and Brief Intervention (Adapted SBI)	Screening and Education with Attention Control (SEA)
Health and wellness approach, handout on tips for healthy living	Health and wellness approach, handout on tips for healthy living
Screening for alcohol and other drug misuse	Screening for alcohol and other drug misuse
Educational video and handout on negative consequences of alcohol use after TBI	Educational video and handout on negative consequences of alcohol use after TBI
Adapted motivational interview with cognitive accommodations, summarized in Brain Health Plan	General discussion about discharge plans
Telephone booster 1 month after discharge, discuss progress with Brain Health Plan and use of strategies	Telephone booster 1 month after discharge, general discussion about current activities and progress

Note. TBI = traumatic brain injury.

interactions that may inadvertently reinforce ideas counter to change (roll with resistance); and d) increase the client's awareness of discrepancies between values and behavior (develop discrepancy). The interviewers could use any information obtained during the baseline assessment (e.g., attribution of injury to substance use, expectancies) to assist the process. Following the interview, the interventionist documented and sent a letter to the research participant including the plan for behavior change, a reminder of the other accommodations they had chosen to help remember to implement the plan, and a reminder that they would be called in a month for a booster session.

The booster session was conducted by phone one-month postdischarge and resumed where the first brief intervention session ended. Prochange decisions, goals, and strategies identified in the first session were reviewed, and progress discussed. Motivational interviewing principles were used to encourage further progress toward readiness to change. If the participant voiced any challenges to change (e.g., development of depressed mood), the interviewer provided advice and referrals for treatment as appropriate. Contact information was verified for the follow-up interviews.

SEA

Following the video presentation, any questions raised by the participant were succinctly answered. The discussion then turned to upcoming discharge plans. The specifics of the discussion were open-ended but did not include additional discussion of substance misuse. Participants were sent a letter following the session to remind them of the one-month postdischarge booster session. The booster session included a discussion on the participants' progress since discharge and problems encountered with the discharge plan. As appropriate, referrals were made to address participant concerns. Contact information was verified for the follow-up interviews.

Intervention Fidelity

The sessions for both groups were audio recorded. The study coordinator provided feedback to the interventionists regarding the treatment fidelity with training and input from the PI, using treatment checklists as well as the Motivational Interviews Skill Code-2 as guides (Miller et al., 2003). The interventionists were provided feedback for the first five interviews, with periodic feedback on a selection of interviews throughout the intervention phase of the project.

Outcomes

Research assistants masked to the assigned condition contacted participants at 3, 6, and 12 months postdischarge from rehabilitation to obtain data on outcomes. The a priori primary outcome was the number of alcoholic drinks per week, however since a large proportion of participants did not resume drinking, we also dichotomized this outcome into abstinent versus resumed drinking. Additional outcomes included whether the participant binged in the past month, whether the participant had used illicit drugs, and the number of facts recalled from the video. We evaluated number of facts recalled from the eight messages presented in the video, using an open-ended question: "How can the use of alcohol or other drugs harm you after a brain injury?" with the interviewer using a checklist to determine if the fact recalled matched any of the eight messages.

The quantity and frequency of alcohol and other drug use was measured using the standard questions developed originally for the Center for Disease Control and Prevention's Behavioral Risk Factor Surveillance System (BRFSS;Nelson et al., 2001) and adopted for use by the TBI model Systems National Database (Corrigan et al., 2003). These questions represent slightly more precise versions of the questions comprising the Quick Drinking Screen (Sobell et al., 2003). The questions query whether any alcohol was consumed, frequency of consumption, quantity of drinks per day, frequency of binging (defined as 5 or more drinks on an occasion for males and females), and use of other illicit drugs or drugs not prescribed to the individual. The weighted averages of test-retest correlations across studies are high for the BRFSS alcohol-related questions, ranging from .84 to .88 (Nelson et al., 2001). Test–retest reliability with participants in the TBI model Systems is represented by ICCs of .78 for drinks/week and .65 for number of binges in past month (Bogner et al., 2017). For dichotomized variables, a Cohen's kappa of .78 was reported for any use of other drugs and .68 for any binge use in past month (Bogner et al., 2017). Studies on concurrent validity have shown strong correlations with related measures, with the weighted averages ranging from .63 to .73 (Nelson et al., 2001).

Of note, at the time of study initiation, modifications to the accepted definitions of binge drinking for women were being made, reducing the amount needed to qualify as a binge to 4 drinks/occasion. This modification was made for the baseline assessment but not carried over to the outcome assessment, such that the binge outcome remained as 5 drinks or more for both men and women.

Baseline Assessment

The baseline assessment included an evaluation of premorbid use of alcohol and other drugs, baseline knowledge of the eight messages related to alcohol use post-TBI, as well as measures of depression and healthy lifestyle behaviors. Data on the injury and recovery were captured from the medical records.

In addition to the BRFSS/TBIMS alcohol and drug questions, several other measures were used to obtain more detailed information about substance misuse for the purposes of determining inclusion and/or obtain data on covariates that should be balanced across groups. The 14-day Timeline Followback interview (TLFB), (Maisto et al., 1982) queried alcohol and other drug use during each day of the first two weeks prior to the injury that they are able to recall. Twenty items from the Alcohol Expectancy Questionnaire-III (AEQ-III; George et al., 1995) were selected to represent the negative and positive expectancies for persons with TBI (selection based on unpublished factor analysis). Expectancies were represented as mean values of Likert ratings, with higher scores indicating greater agreement with items expressing negative or positive expectations. Attribution of the injury to substance misuse was assessed using four questions querying whether alcohol or other, unprescribed drugs were consumed within two hours prior to the incident leading to injury, and a Likert rating of 1 to 5 indicating the degree to which they believe their use caused the injury (higher indicates greater attribution). Attribution of injury to alcohol use has been found to mediate drinking outcomes in other studies (Barnett et al., 2010). The MINI International Neuropsychiatric Interview (Sheehan et al., 1998) was used to identify participants with substance misuse or dependence (based on *DSM–IV* criteria).

The Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) was used as a self-report measure of depressive symptoms experienced during the previous two weeks. The PHQ-9 has been used successfully to measure depressive symptoms of persons with TBI, although a conversion to a dichotomous variable indicating depressed versus not depressed is recommended and was used in the current study (Fann et al., 2005).

The Health-Promoting Lifestyle Profile II is 52-item measure of health promoting behavior (Walker et al., 1987). The items use a Likert rating scale of the frequency of engagement in healthy behaviors, with higher scores indicating healthier behaviors. The scale has been validated across multiple cultures and used successfully with persons with TBI (Braden et al., 2012; Brenner et al., 2012; Hulme et al., 2003; Pinar et al., 2009; Pérez-Fortis et al., 2012; Sousa et al., 2015; Tajik et al., 2010). For the purpose of this research, three of the subscales were used: Physical Activity, Nutrition and Stress Management.

Analyses

Baseline demographic and clinical characteristics were compared across randomized groups using t-tests and chi-square tests as appropriate. Mixed models were used to test the intervention's effect on continuous outcomes (drinks per week, the number of facts recalled about the negative effects of substance misuse). Fixed effects included time (treated as a categorical variable), intervention group, their interaction, and baseline outcome levels. Of primary interest were preplanned contrasts comparing group means at each of the three postrandomization time points. An unstructured variance-covariance structure was used to account for within-subject correlation (repeated outcome interviews). The Kenward-Roger adjustment to the degrees of freedom was used to control type I error rates. Models for the intervention's effect on dichotomous outcomes (alcohol use, binge use) were estimated using generalized estimating equations with an independent working correlation structure and robust standard errors to capture the within-subject correlation. Fixed effects included were the same as models on continuous outcomes. Sensitivity analyses further included the effects of unbalanced covariates and treatment dose (if a booster was received). Exploratory analyses used a similar approach to evaluate a) the intervention's effect on other drug use, b) the impact on other healthy behaviors (nutrition, exercise, and stress management), and c) whether other healthy behaviors were associated with alcohol use at follow-up. A two-sided significance level of $\alpha = .05$ was used for all tests. Analyses were performed in SAS Version 9.4 (SAS institute, Cary, NC).

Results

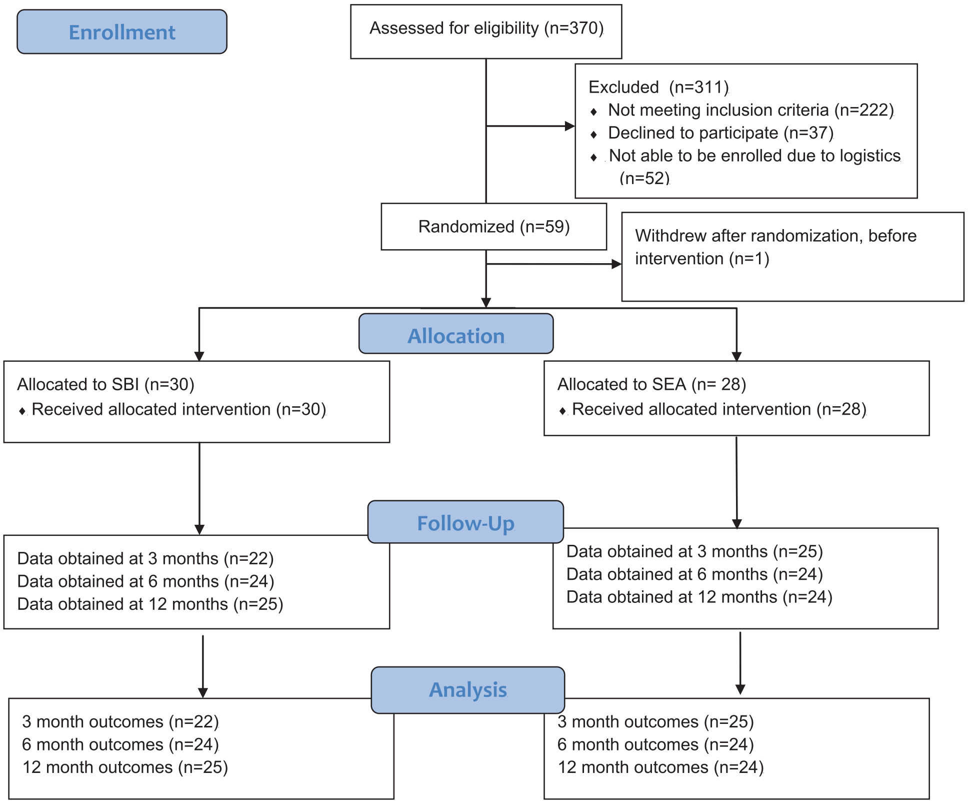
From March, 2014 to July, 2017, fifty-nine participants met criteria and agreed to be randomized into the study. One participant was excluded from the analysis because they withdrew from the study before the intervention could be delivered. The final sample size was 58. Thirty participants were randomized to Adapted SBI and 28 to SEA (see Figure 1). Five participants in the SEA group and 11 participants in the Adapted SBI group did not receive a booster session; booster participation did not significantly differ between the groups ($\chi^2 = 2.56$, $df = 1$, $p = .11$). Eighty-four percent of the sample ($n = 49$) was successfully followed at the 12-month time point and 71% ($n = 41$) were followed at all 3 time points. Attrition at 12 months did not differ across the two intervention conditions (Fisher's exact test p-value = .99). No significant differences were observed between those followed and those lost on the following baseline variables: age, sex, race, married versus not, educational level, employed versus not, illicit drug use, alcohol binging, drinks per week, depression, length of posttraumatic amnesia, Functional Independence Measure (FIM) Motor and Cognitive at admission and discharge, nutrition, stress management, or physical activity. See the Figure 1, participant Flow Diagram, for more information on the screening and flow of participants.

The randomization was generally successful with balancing the baseline covariates (see Table 2). However, while not statistically significant, there were some variables that were relatively unbalanced between the groups: FIM Cognitive at admission and discharge (Adapted SBI more impaired, $p = .05$), average negative alcohol expectancies (Adapted SBI higher, $p = .09$), participant report of drinking alcohol or using other drugs 2 hr before the injury (Adapted SBI more likely, $p = .09$ and $p = .11$, respectively), participant attribution of alcohol as cause of injury (Adapted SBI more likely, $p = .05$), and the number of symptoms of a substance use disorder (SUD) other than alcohol (Adapted SBI more symptoms, $p = .10$). To prevent overfitting and multicollinearity, only the following covariates were used in the adjusted models: FIM Cognitive at discharge, attributing alcohol as cause of injury, negative expectancies, and number of symptoms of a SUD other than alcohol.

For the full sample at baseline, the mean number of drinks per week was 28.8 ($SD = 40.7$) with a median of 14. The mean number of binges per month was 8.9 ($SD = 10.5$) and the median was 4. At baseline, 53% of the sample met criteria for heavy drinking based on drinks/week by sex and/or binging at least 5 times per month (Substance Abuse and Mental Health Services Administration, 2019). Twenty-nine percent had used other drugs during the year prior to the injury. By the 12-month follow-up, the median number of drinks per week and episodes of binge drinking was 0, and 14% had used other drugs. Eleven (37%) of the Adapted SBI participants and 7 (25%) of the SEA participants reported that they were receiving SUD treatment at the time of at least one of the follow-up interviews.

No significant differences were found between the treatment conditions for the number of drinks consumed per week. Differences were detected between the groups on the percentage of participants who remained abstinent of alcohol use after discharge. The SEA group gradually resumed use over the course of the year, with 62% of the group resuming use by 12 months. In contrast, the percentage of participants consuming alcohol in the Adapted SBI group remained steady at approximately 30% across all three time periods (see Table 3). No significant differences were found for binge use, drug use, or the number of facts recalled about the negative effects of substance misuse. The selected unbalanced covariates were added to the models to test whether the lack of balance impacted the findings. The inferences did not change with any of the outcomes when the unbalanced covariates were included in the

Figure 1
Participant Flow Diagram



Note. SEA = Screening and Education with Attention Control. See the online article for the color version of this figure.

models. Likewise, inferences did not change when the sample was limited to those who received the booster session.

Given that a large proportion of the sample did not resume drinking, differences in drinks per week between the groups may be more difficult to detect (though robust standard errors were used to correct for the skewness). In order to evaluate whether those who resumed drinking differed by group in the amount they drank, a posthoc analysis was conducted using only participants who had resumed alcohol use by 12 months ($n = 23$). Controlling for preinjury baseline drinks/week, No Group × Time Effect was noted. Both groups showed an increase in use over time ($p = .03$). The Adapted SBI group consumed more drinks per week at 3 months (Adapted SBI $M = 3.43 \pm .96$, SEA $M = .72 \pm .66$, $p = .03$), but no differences were observed at the other time points. To understand the meaning of the longitudinal trajectory, the marginal means and their 95th percentile confidence intervals at preinjury baseline and each follow-up time point were plotted in Figure 2, using only those participants with data at all 4 time points ($n = 20$). As shown, there was large variability at preinjury baseline. Adapted SBI participants who had returned to drinking by 12 months had marginally higher baseline levels of drinking than SEA participants. By 12 months, both groups exhibited lower levels of drinking relative to their baseline levels.

The exploratory analysis indicated no intervention effects on any of the healthy behaviors, including nutrition, exercise and stress management. When the resumption of alcohol use at 12 months was the independent variable, less healthy nutrition was observed at all 4 time points for those who had resumed alcohol use by 12 months versus those who had not ($p = .03$) and a similar trend was observed for stress management ($p = .08$). Physical activity at any time point did not show a significant relationship with alcohol use at 12 months ($p = .35$).

Discussion

The current study sought to evaluate the effectiveness of a brief intervention for reducing alcohol misuse that includes screening, education, motivational interviewing, and accommodations for cognitive deficits (Adapted SBI) relative to the effects of an intervention that is limited to screening and education (SEA). The study did not find an effect on the primary endpoint, the number of drinks consumed per week at 12 months postdischarge. Overall, the amount of alcohol consumed by participants in either condition was very low, with a median of 0 drinks per week. However, differences between the conditions were found in the percentage of participants who resumed any alcohol consumption. The proportion of SEA participants resuming alcohol use steadily increased throughout the year while the proportion drinking in the Adapted SBI group did not change substantively. Only about 30% of participants in the Adapted SBI group were drinking at any follow-up time point. However, by 12 months, about twice as many participants in the SEA group (62%) were drinking as those in the

Table 2
Demographic and Baseline Characteristics for Full Sample and by Group

Characteristics	Total (*N* = 58)	Adapted SBI (*N* = 30)	SEA (*N* = 28)	*p*-value
Age	39.2 ± 14.6 (18.8–81)	38.1 ± 12.6 (18.7–58)	40.4 ± 16.6 (20–81)	.56
Sex				.34
Male	40 (69%)	19 (63.3%)	21 (75%)	
Female	18 (31%)	11 (36.7%)	7 (25%)	
Race				.25
White	51 (87.9%)	28 (93.3%)	23 (82.1%)	
Black	7 (12.1%)	2 (6.7%)	5 (17.9%)	
Marital status				.29
Married	15 (25.9%)	6 (20%)	9 (32.1%)	
Not married	43 (74.1%)	24 (80%)	19 (67.9%)	
Education				.58
Less than HS	11 (19%)	7 (23.3%)	4 (14.3%)	
HS diploma or GED	19 (32.8%)	8 (26.7%)	11 (39.3%)	
Greater than HS	28 (48.3%)	15 (50%)	13 (46.4%)	
Primary employment status				.51
Not competitively employed	11 (19%)	7 (23.3%)	4 (14.3%)	
Competitively employed	47 (81%)	23 (76.7%)	24 (85.7%)	
Drug usage before injury				.49
Yes	17 (29.3%)	10 (33.3%)	7 (25%)	
No	41 (70.7%)	20 (66.7%)	21 (75%)	
Length of rehabilitation stay, days	15.7 ± 7.6 (4–42)	15.3 ± 7.5 (7–42)	16.2 ± 7.8 (4–33)	.65
Length of acute stay, days	18.1 ± 15.9 (4–110)	19.5 ± 19.5 (4–110)	16.5 ± 11.0 (5–53)	.48
Time from injury to intervention	33.8 + 21.7 (10–126)	33.7 + 23.1 (10–126)	34.7 + 21.2 (12–115)	.94
Cause of Injury				.81
Motor vehicle crash	30 (51.7%)	17 (56.7%)	13 (46.4%)	
Violence	7 (12.1%)	4 (13.3%)	3 (10.7%)	
Sports/other	5 (8.6%)	2 (6.7%)	3 (10.7%)	
Fall	16 (27.6%)	7 (23.3%)	9 (32.1%)	
Number of days in posttraumatic amnesia	19.7 ± 19.9 (0–114)	22.8 ± 22.8 (0–114)	16.2 ± 15.7 (0–61)	.23
GCS at admission				.40
Sedated/Intubated	24 (45.3%)	15 (55.6%)	9 (34.6%)	
2–8	6 (11.3%)	2 (7.4%)	4 (15.4%)	
9–12	3 (5.7%)	2 (7.4%)	1 (3.9%)	
13–15	20 (37.7%)	8 (29.6%)	12 (46.2%)	
Alcohol use before injury				NA
Yes	58 (100%)	30 (100%)	28 (100%)	
No	0 (0%)	0 (0%)	0 (0%)	
Drinks per week	28.8 ± 40.7 (0.75–225)	35.3 ± 49.2 (0.75–225)	21.8 ± 28.4 (1–112)	.20
Number of binges per month	8.9 ± 10.5 (0–30)	10.3 ± 11.3 (0–30)	7.3 ± 9.5 (0–30)	.27
FIM motor at admission	44.6 ± 16.8 (14–78)	47.6 ± 17.9 (14–78)	41.4 ± 15.1 (17–66)	.16
FIM cognitive at admission	16.6 ± 6.9 (5–30)	14.9 ± 6.9 (5–30)	18.5 ± 6.6 (5–28)	.05
FIM motor at discharge	70.6 ± 13.9 (24–88)	72.7 ± 12.9 (35–88)	68.4 ± 14.7 (24–86)	.24
FIM cognitive at discharge	24.7 ± 3.9 (16–32)	23.7 ± 3.5 (16–30)	25.8 ± 4.1 (17–32)	.05
HPLP II nutrition	2.4 ± 0.5 (1.2–3.7)	2.4 ± 0.5 (1.7–3.7)	2.3 ± 0.6 (1.2–3.6)	.30
HPLP II physical activity	2.3 ± 0.6 (1.3–3.6)	2.4 ± 0.7 (1.4–3.6)	2.2 ± 0.6 (1.3–3.5)	.29
HPLP II stress management	2.6 ± 0.6 (1.1–4)	2.7 ± 0.6 (1.1–4)	2.5 ± 0.6 (1.4–3.4)	.16
Fact total	1.5 ± 1.0 (0–4)	1.5 ± 0.9 (0–3)	1.5 ± 1.0 (0–4)	.99
Presence of Depression: PHQ-9				.67
No	42 (72.4%)	21 (70%)	21 (75%)	
Yes	16 (27.6%)	9 (30%)	7 (25%)	
Negative expectancies	4.0 ± 1.4 (1–6)	4.3 ± 1.4 (1.2–6)	3.7 ± 1.3 (1–6)	.09
Positive expectancies	3.6 ± 1.2 (1.1–5.8)	3.7 ± 1.3 (1.1–5.8)	3.6 ± 1.1 (1.6–5.4)	.80
Did you drink any alcoholic beverage within 2 hours before your injury				.09
No	33 (58.9%)	14 (48.3%)	19 (70.4%)	
Yes	23 (41.1%)	15 (51.7%)	8 (29.6%)	
Did you take any drugs that weren't prescribed to you within 2 hours before your injury				.11
No	53 (93%)	26 (86.7%)	27 (100%)	
Yes	4 (7%)	4 (13.3%)	0 (0%)	
Attribution of injury to alcohol	1.9 ± 1.6 (1–5)	2.3 ± 1.8 (1–5)	1.5 ± 1.2 (1–5)	.05
Attribution of injury to unprescribed drugs	1.1 ± 0.4 (1–4)	1.2 ± 0.6 (1–4)	1 ± 0 (1-1)	.23
MINI Number of alcohol use disorder symptoms	3.8 ± 3.1 (0–11)	4.3 ± 3.3 (0–11)	3.4 ± 2.7 (0–11)	.24
MINI Lifetime alcohol use disorder				.86
No AUD	13 (22.4%)	7 (23.3%)	6 (21.4%)	
AUD	45 (77.6%)	23 (76.7%)	22 (78.6%)	

(*table continues*)

Table 2 (*continued*)

Characteristics	Total (*N* = 58)	Adapted SBI (*N* = 30)	SEA (*N* = 28)	*p*-value
MINI Have you ever taken any of these drugs more than once to get high, to feel better, or change your mood?				.27
No	33 (56.9%)	15 (50%)	18 (64.3%)	
Yes	25 (43.1%)	15 (50%)	10 (35.7%)	
MINI Count of symptoms for drug 1	1.6 ± 2.8 (0−9)	2.1 ± 3.1 (0−9)	0.9 ± 2.2 (0−8)	.10

Note. Adapted SBI = Screening and Brief Intervention; SEA = Screening and Education with Attention Control; GCS = Glasgow Coma Scale; FIM = Functional Independence Measure; HPLP-II = Health Promoting Lifestyle Profile-II; MINI = Mini International Neuropsychiatric Interview; AUD = Alcohol use disorder; PHQ-9 = Patient Health Questionnaire-9; NA = not applicable. Data were presented as *N* (%) or *M* ± *SD* (range).

Adapted SBI group (32%). The strength of this intervention effect is remarkable in light of the much more modest findings observed in previous studies of brief interventions with persons with brain injury.

The findings of the current study also contrast with other studies that show minimal effects with participants with heavy baseline alcohol misuse (Barata et al., 2017; Saitz, 2010a). Generally, SBI/SBIRT has not been recommended for people with more severe alcohol use disorders due to reduced effectiveness relative to less severe alcohol use; however the findings of the current study, which controlled for preinjury baseline alcohol misuse, suggest that Adapted SBI can be effective with persons with both TBI and heavy baseline alcohol misuse. While speculative at this point, one possible mechanism for increasing effectiveness among persons with heavy alcohol use may be through engagement in ongoing SUD treatment as a result of the brief intervention.

The secondary analyses provided some insights that may assist with understanding the results and their clinical application, as well as questions to be addressed in future research. Some of the Adapted SBI participants who had resumed drinking by 12 months had higher preinjury baseline levels of alcohol use than their SEA counterparts. In addition, trends suggested that prior to the intervention, the Adapted SBI group as a whole reported more symptoms of a drug use disorder other than alcohol. Their more severe disorder likely challenged the effectiveness of the Adapted SBI intervention, yet it is still notable that their overall amount of alcohol use at 12 months was still substantially lower than preinjury baseline. There was also no evidence that they substituted another drug for alcohol, as only one person in each of the groups became a new user of other drugs. The findings highlight the need to identify additional factors determining responsiveness to treatment by persons with more severe alcohol use disorders.

The lack of an effect on misuse of drugs other than alcohol was disappointing but not surprising given that only 29% of the participants misused other drugs at preinjury baseline. Given the unique and varied effects of the range of drug classes, it is likely that the intervention requires some modifications to increase effectiveness with other drug use disorders.

The intervention was framed in the context of overall health and wellness. We had hoped that this approach would encourage participation, however the consenting process still emphasized the intent to reduce substance misuse (e.g., title of the project), negating the potential impact of the reframed approach on participant accrual. However, the health and wellness approach did provide

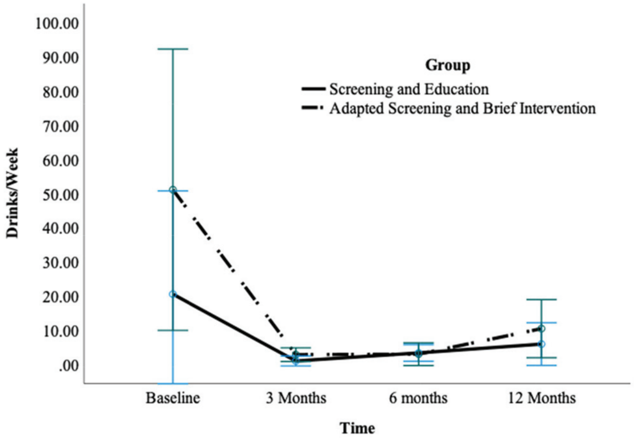
Table 3
Intervention Effects on Outcomes, Controlling for Baseline

Outcome by follow-up point	SBI*	SEA*	Group difference	95% CI	*p*-value	Time *p*-value	Group × Time *p*-value
Average drinks per week						.01	.13
3-month	1.01 (0.39)	0.47 (0.37)	0.54 (0.55)	[−0.56, 1.64]	.33		
6-month	1.04 (0.66)	2.14 (0.65)	−1.10 (0.93)	[−2.97, 0.76]	.24		
12-month	3.15 (1.58)	3.61 (1.61)	−0.47 (2.26)	[−5.0, 4.07]	.84		
Any alcohol use						<.001	.01
3-month	27% (6)	16% (4)	1.97	[0.47, 8.17]	.35		
6-month	29% (7)	46% (11)	0.49	[0.15, 1.60]	.24		
12-month	32% (8)	62% (15)	0.28	[0.09, 0.92]	.04		
Any binging past month^							
3-month	5% (1)	0% (0)	NA	NA	.47		
6-month	12% (3)	21% (5)	NA	NA	.70		
12-month	16% (4)	21% (5)	NA	NA	.73		
Fact total score						.09	.95
3-month	1.52 (0.15)	1.36 (0.14)	0.16 (0.21)	[−0.26, 0.58]	.44		
6-month	1.32 (0.15)	1.24 (0.15)	0.08 (0.21)	[−0.33, 0.50]	.69		
12-month	1.58 (0.16)	1.45 (0.16)	0.13 (0.22)	[−0.32, 0.57]	.57		
Any other illicit drug use^						NA	NA
3-month	18% (4)	12% (3)	NA	NA	.69		
6-month	21% (5)	17% (4)	NA	NA	.99		
12-month	16% (4)	12% (3)	NA	NA	.99		

Note. SBI = Screening and Brief Interventions; SEA = Screening and Education with Attention Control; NA = not applicable.
^ Fisher-exact tests were run on binge and drug use due to small cell size. Thus, time main effect and group by time effect were not reported.
* Least square means (robust standard error) or percentage (*n*).

Figure 2

Only Participants Who Resumed Drinking by 12 Months



Note. Estimated marginal means (with 95% confidence intervals) of drinks/week by group at each time point. See the online article for the color version of this figure.

some interesting insights. While we did not find an intervention effect on healthy behaviors, we found that better nutrition was observed among individuals who did not resume alcohol use at 12 months and a trend suggested that they used more effective stress management strategies. These differences were present at preinjury baseline and maintained through follow-up. If the intervention was modified to further capitalize on the participant's strongest healthy behaviors, it might be possible to enhance the intervention's effect on the resumption of alcohol misuse, as well as other prohealth behaviors such as healthy food consumption. Since alcohol misuse may also impact food choices leading to better or worse nutrition outcomes, this approach may also impact overall health outcomes and recovery trajectory in individuals with moderate or severe TBI (Erdman et al., 2011; Olsen & Nesbitt, 2010)

Limitations of the study include marginal imbalance on some important covariates despite randomization, however models that adjusted for unbalanced covariates suggested minimal impact. The final sample size was smaller than indicated by the original power analysis based on a medium effect ($n = 70$). Recruitment of qualified participants was hampered by a short length of stay. Patients were often discharged before or within days of regaining the cognitive ability to participate in the intervention. Sixteen percent of the sample was lost to follow-up, however no significant differences were noted between those found and those lost to follow-up. Sixteen participants did not receive a booster session, and yet the lack of a booster session did not impact the findings (though power was limited to detect a difference). The sampling strategy did not allow for an adequate test of whether the intervention could be effective with reducing illicit drug use. In addition, the questions about drug use may not have adequately captured various nuances, such as whether the participant misused medications that had been prescribed to them. Within the field, the definition of binge use changed during the conduct of the study, moving from defining binge use as 5 drinks or more at an occasion for any sex to allowing that 4 drinks per occasion is better representative of binge use for women. While we had adjusted the definition for differentiation by sex at preinjury baseline, we failed to do so for the outcome measure. Given the substantial reduction in the amount of alcohol use by both groups at follow-up, the likelihood that this oversight changed the overall findings of the study is minimal. In the context of the Adapted SBI intervention, it was believed that cognitive accommodations should be based on perceived needs formed via a collaboration between the interventionist and the participant. Neuropsychological test performance was not used to characterize deficits that require cognitive accommodations, but future studies could evaluate whether testing could be an effective augmentation.

Conclusions

While significant effects were not observed with the primary outcome variable (drinks/week), screening, education, and brief intervention adapted using cognitive accommodations appeared to be more effective at preventing the resumption of alcohol use when compared to screening and education alone. These effects were observed even when some participants only received one session. The use of a health and wellness approach provided insight into the potential role of other health behaviors in the resumption of substance misuse following TBI, and deserve additional study.

References

Adams, R. S., Corrigan, J. D., & Larson, M. J. (2012). Alcohol use after combat-acquired traumatic brain injury: What we know and don't know. *Journal of Social Work Practice in the Addictions*, *12*(1), 28–51. https://doi.org/10.1080/1533256X.2012.647580

Bannon, S. M., Kumar, R. G., Bogner, J., O'Neil-Pirozzi, T. M., Spielman, L., Watson, E. M., & Dams-O'Connor, K. (2021). Reinjury after moderate to severe TBI: Rates and risk factors in the NIDILRR Traumatic Brain Injury Model Systems. *The Journal of Head Trauma Rehabilitation*, *36*(1), E50. https://doi.org/10.1097/HTR.0000000000000586

Barata, I. A., Shandro, J. R., Montgomery, M., Polansky, R., Sachs, C. J., Duber, H. C., Weaver, L. M., Heins, A., Owen, H. S., Josephson, E. B., & Macias-Konstantopoulos, W. (2017). Effectiveness of SBIRT for alcohol use disorders in the Emergency Department: A systematic review. *The Western Journal of Emergency Medicine*, *18*(6), 1143–1152. https://doi.org/10.5811/westjem.2017.7.34373

Barnett, N. P., Apodaca, T. R., Magill, M., Colby, S. M., Gwaltney, C., Rohsenow, D. J., & Monti, P. M. (2010). Moderators and mediators of two brief interventions for alcohol in the emergency department. *Addiction*, *105*(3), 452–465. https://doi.org/10.1111/j.1360-0443.2009.02814.x

Beaulieu-Bonneau, S., St-Onge, F., Blackburn, M. C., Banville, A., Paradis-Giroux, A. A., & Ouellet, M. C. (2018). Alcohol and drug use before and during the first year after traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *33*(3), E51–E60. https://doi.org/10.1097/HTR.0000000000000341

Bogner, J. A., Whiteneck, G. G., MacDonald, J., Juengst, S. B., Brown, A. W., Philippus, A. M., Marwitz, J. H., Lengenfelder, J., Mellick, D., Arenth, P., & Corrigan, J. D. (2017). Test-retest reliability of traumatic brain injury outcome measures: A traumatic brain injury model systems study. *The Journal of Head Trauma Rehabilitation*, *32*(5), E1. https://doi.org/10.1097/HTR.0000000000000291

Bogner, J., & Corrigan, J. D. (2013). Interventions for substance misuse following TBI: As systematic review. *Brain Impairment*, *14*(1), 77–91. https://doi.org/10.1017/BrImp.2013.5

Braden, C. A., Cuthbert, J. P., Brenner, L., Hawley, L., Morey, C., Newman, J., Staniszewski, K., & Harrison-Felix, C. (2012). Health and wellness characteristics of persons with traumatic brain injury. *Brain Injury*, *26*(11), 1315–1327. https://doi.org/10.3109/02699052.2012.706351

Brenner, L. A., Braden, C. A., Bates, M., Chase, T., Hancock, C., Harrison-Felix, C., Hawley, L., Morey, C., Newman, J., Pretz, C., & Staniszewski, K. (2012). A health and wellness intervention for those with moderate to severe traumatic brain injury: A randomized controlled trial. *The Journal of Head Trauma Rehabilitation*, *27*(6), E57–E68. https://doi.org/10.1097/HTR.0b013e318273414c

Cabé, N., Lanièpce, A., & Pitel, A. L. (2021). Physical activity: A promising adjunctive treatment for severe alcohol use disorder. *Addictive Behaviors*, *113*, 106667. https://doi.org/10.1016/j.addbeh.2020.106667

Chang, H.-K., Hsu, J.-W., Wu, J.-C., Huang, K.-L., Chang, H.-C., Bai, Y.-M., Chen, T.-J., & Chen, M.-H. (2019). Risk of attempted suicide among adolescents and young adults with traumatic brain injury: A nationwide longitudinal study. *Journal of Affective Disorders*, *250*, 21–25. https://doi.org/10.1016/j.jad.2019.02.059

Corrigan, J. D. (1995). Substance abuse as a mediating factor in outcome from traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *76*(4), 302–309. https://doi.org/10.1016/S0003-9993(95)80654-7

Corrigan, J. D. (2004). *Substance use disorders following traumatic brain injury: Final report for Ohio Trauma Registry grant* [Unpublished manuscript]. Ohio State University.

Corrigan, J. D. (2005). Substance abuse. In W. M. High, A. M. Sander, M. A. Struchen, & K. A. Hart (Eds.), *Rehabilitation for traumatic brain injury* (pp. 133–155). Oxford University Press.

Corrigan, J. D., Bogner, J., Hungerford, D. W., & Schomer, K. (2010). Screening and brief intervention for substance misuse among patients with traumatic brain injury. *The Journal of Trauma*, *69*(3), 722–726. https://doi.org/10.1097/TA.0b013e3181e904cc

Corrigan, J. D., Bogner, J., Lamb-Hart, G., & Sivak-Sears, N. (2003). *Technical report on problematic substance use variables*. Thew Center for Outcome Measurement in Brain Injury.

Dai, C. L., Chen, C. C., Richardson, G. B., & Gordon, H. R. D. (2020). Managing substance use disorder through a walking/running training program. *Substance Abuse: Research and Treatment*. Advance online publication. https://doi.org/10.1177/1178221820936681

Erdman, J., Oria, M., & Pillsbury, L. (2011). *Nutrition and traumatic brain injury: Improving acute and subacute health outcomes in military personnel*. National Academies Press.

Fann, J. R., Bombardier, C. H., Dikmen, S., Esselman, P., Warms, C. A., Pelzer, E., Rau, H., & Temkin, N. (2005). Validity of the Patient Health Questionnaire-9 in assessing depression following traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *20*(6), 501–511. https://doi.org/10.1097/00001199-200511000-00003

George, W. H., Frone, M. R., Cooper, M. L., Russell, M., Skinner, J. B., & Windle, M. (1995). A revised Alcohol Expectancy Questionnaire: Factor structure confirmation, and invariance in a general population sample. *Journal of Studies on Alcohol*, *56*(2), 177–185. https://doi.org/10.15288/jsa.1995.56.177

Hart, T., Benn, E. K. T., Bagiella, E., Arenth, P., Dikmen, S., Hesdorffer, D. C., Novack, T. A., Ricker, J. H., & Zafonte, R. (2014). Early trajectory of psychiatric symptoms after traumatic brain injury: Relationship to patient and injury characteristics. *Journal of Neurotrauma*, *31*(7), 610–617. https://doi.org/10.1089/neu.2013.3041

Hulme, P. A., Walker, S. N., Effle, K. J., Jorgensen, L., McGowan, M. G., Nelson, J. D., & Pratt, E. N. (2003). Health-promoting lifestyle behaviors of Spanish-speaking Hispanic adults. *Journal of Transcultural Nursing*, *14*(3), 244–254. https://doi.org/10.1177/1043659603014003011

Joint Commission. (2007). *Specifications manual for national hospital inpatient quality measures*. American College of Surgeons.

Kaner, E. F., Beyer, F. R., Muirhead, C., Campbell, F., Pienaar, E. D., Bertholet, N., Daeppen, J. B., Saunders, J. B., & Burnand, B. (2018). Effectiveness of brief alcohol interventions in primary care populations. *Cochrane Database of Systematic Reviews*, *2*, CD004148. https://doi.org/10.1002/14651858.CD004148.pub4

Kennedy, E., Cohen, M., & Munafò, M. (2017). Childhood traumatic brain injury and the associations with risk behavior in adolescence and young adulthood: A systematic review. *The Journal of Head Trauma Rehabilitation*, *32*(6), 425–432. https://doi.org/10.1097/HTR.0000000000000289

Kennedy, E., Heron, J., & Munafò, M. (2017). Substance use, criminal behaviour and psychiatric symptoms following childhood traumatic brain injury: Findings from the ALSPAC cohort. *European Child & Adolescent Psychiatry*, *26*(10), 1197–1206. https://doi.org/10.1007/s00787-017-0975-1

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Lau, K., Freyer-Adam, J., Gaertner, B., Rumpf, H. J., John, U., & Hapke, U. (2010). Motivation to change risky drinking and motivation to seek help for alcohol risk drinking among general hospital inpatients with problem drinking and alcohol-related diseases. *General Hospital Psychiatry*, *32*(1), 86–93. https://doi.org/10.1016/j.genhosppsych.2009.10.002

MacLeod, J. B., & Hungerford, D. W. (2011). Alcohol-related injury visits: Do we know the true prevalence in U.S. trauma centres? *Injury*, *42*(9), 922–926. https://doi.org/10.1016/j.injury.2010.01.098

Maisto, S. A., Sobell, L. C., Cooper, A. M., & Sobell, M. B. (1982). Comparison of two techniques to obtain retrospective reports of drinking behavior from alcohol abusers. *Addictive Behaviors*, *7*(1), 33–38. https://doi.org/10.1016/0306-4603(82)90022-3

Makdissi, R., & Stewart, S. H. (2013). Care for hospitalized patients with unhealthy alcohol use: A narrative review. *Addiction Science & Clinical Practice*, *8*(1), 11. https://doi.org/10.1186/1940-0640-8-11

Marcoux, J., Alkutbi, M., Lamoureux, J., Feyz, M., Saluja, R. S., & de Guise, E. (2017). Discharge Against Medical Advice in Traumatic Brain Injury: Follow-Up and Readmission Rate. *The Canadian Journal of Neurological Sciences*, *44*(3), 311–317. https://doi.org/10.1017/cjn.2016.241

McKinlay, A., Corrigan, J., Horwood, L. J., & Fergusson, D. M. (2014). Substance abuse and criminal activities following traumatic brain injury in childhood, adolescence, and early adulthood. *The Journal of Head Trauma Rehabilitation*, *29*(6), 498–506. https://doi.org/10.1097/HTR.0000000000000001

McQueen, J., Howe, T. E., Allan, L., Mains, D., & Hardy, V. (2011). Brief interventions for heavy alcohol users admitted to general hospital wards. *Cochrane Database of Systematic Reviews*, *8*, CD005191. https://doi.org/10.1002/14651858.CD005191.pub3

Miller, W. R., & Rollnick, S. (2013). *Motivational interviewing: Helping people change* (3rd ed.). Guilford Press Press.

Miller, W., Moyers, T., Ernst, D., & Amrhein, P. (2003). *Manual for the Motivational Interviewing Skills Code, version 2.0*. https://motivationalinterviewing.org/sites/default/files/MISC2.pdf

Minugh, P. A., Nirenberg, T. D., Clifford, P. R., Longabaugh, R., Becker, B. M., & Woolard, R. (1997). Analysis of alcohol use clusters among subcritically injured emergency department patients. *Academic Emergency Medicine*, *4*(11), 1059–1067. https://doi.org/10.1111/j.1553-2712.1997.tb03680.x

Nelson, D. E., Holtzman, D., Bolen, J., Stanwyck, C. A., & Mack, K. A. (2001). Reliability and validity of measures from the Behavioral Risk Factor Surveillance System (BRFSS). *Sozial- Und Praventivmedizin*, *46* (Suppl. 1), S3–S42.

O'Connor, E. A., Perdue, L. A., Senger, C. A., Rushkin, M., Patnode, C. D., Bean, S. I., & Jonas, D. E. (2018). Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: updated evidence report and systematic review for the U.S. Preventive Services Task Force. *Journal of the American Medical Association*, *320*(18), 1910–1928. https://doi.org/10.1001/jama.2018.12086

O'Donnell, A., Anderson, P., Newbury-Birch, D., Schulte, B., Schmidt, C., Reimer, J., & Kaner, E. (2014). The impact of brief alcohol interventions in primary healthcare: A systematic review of reviews. *Alcohol and Alcoholism*, *49*(1), 66–78. https://doi.org/10.1093/alcalc/agt170

Olsen, J. M., & Nesbitt, B. J. (2010). Health coaching to improve healthy lifestyle behaviors: An integrative review. *American Journal of Health Promotion*, *25*(1), e1–e12. https://doi.org/10.4278/ajhp.090313-LIT-101

Olson-Madden, J. H., Brenner, L. A., & Corrigan, J. D. (2012). *Substance use and traumatic brain injury: risk reduction and prevention. Cameron Walker Interactive Design*. https://doi.org/10.1155/2012/174579

Parry-Jones, B. L., Vaughan, F. L., & Miles Cox, W. (2006). Traumatic brain injury and substance misuse: A systematic review of prevalence and outcomes research (1994-2004). *Neuropsychological Rehabilitation*, *16*(5), 537–560. https://doi.org/10.1080/09602010500231875

Pérez-Fortis, A., Ulla Díez, S. M., & Padilla, J. L. (2012). Psychometric properties of the Spanish version of the Health-Promoting Lifestyle Profile II. *Research in Nursing & Health*, *35*(3), 301–313. https://doi.org/10.1002/nur.21470

Pinar, R., Celik, R., & Bahcecik, N. (2009). Reliability and construct validity of the Health-Promoting Lifestyle Profile II in an adult Turkish population. *Nursing Research*, *58*(3), 184–193. https://doi.org/10.1097/NNR.0b013e31819a8248

Ponsford, J., Tweedly, L., & Taffe, J. (2013). The relationship between alcohol and cognitive functioning following traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *35*(1), 103–112. https://doi.org/10.1080/13803395.2012.752437

Ponsford, J., Whelan-Goodinson, R., & Bahar-Fuchs, A. (2007). Alcohol and drug use following traumatic brain injury: A prospective study. *Brain Injury*, *21*(13-14), 1385–1392. https://doi.org/10.1080/02699050701796960

Saitz, R. (2010a). Alcohol screening and brief intervention in primary care: Absence of evidence for efficacy in people with dependence or very heavy drinking. *Drug and Alcohol Review*, *29*(6), 631–640. https://doi.org/10.1111/j.1465-3362.2010.00217.x

Saitz, R. (2010b). Candidate performance measures for screening for, assessing, and treating unhealthy substance use in hospitals: Advocacy or evidence-based practice? *Annals of Internal Medicine*, *153*(1), 40–43. https://doi.org/10.7326/0003-4819-153-1-201007060-00008

Sander, A. M., Bogner, J., Nick, T. G., Clark, A. N., Corrigan, J. D., & Rozzell, M. (2012). A randomized controlled trial of brief intervention for problem alcohol use in persons with traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *27*(5), 319–330. https://doi.org/10.1097/HTR.0b013e318269838c

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for *DSM–IV* and ICD-10. *The Journal of Clinical Psychiatry*, *59*(Suppl. 20), 22–33.

Simonton, A. J., Young, C. C., & Johnson, K. E. (2018). Physical Activity Interventions to Decrease Substance Use in Youth: A Review of the Literature. *Substance Use & Misuse*, *53*(12), 2052–2068. https://doi.org/10.1080/10826084.2018.1452338

Singh, R., Choudhri, K., Sinha, S., Mason, S., Lecky, F., & Dawson, J. (2019). Global outcome after traumatic brain injury in a prospective cohort. *Clinical Neurology and Neurosurgery*, *186*, 105526. https://doi.org/10.1016/j.clineuro.2019.105526

Sobell, L. C., Agrawal, S., Sobell, M. B., Leo, G. I., Young, L. J., Cunningham, J. A., & Simco, E. R. (2003). Comparison of a quick drinking screen with the timeline followback for individuals with alcohol problems. *Journal of Studies on Alcohol and Drugs*, *64*(6), 858–861. https://doi.org/10.15288/jsa.2003.64.858

Sousa, P., Gaspar, P., Vaz, D. C., Gonzaga, S., & Dixe, M. A. (2015). Measuring health-promoting behaviors: Cross-cultural validation of the Health-Promoting Lifestyle Profile-II. *International Journal of Nursing Knowledge*, *26*(2), 54–61. https://doi.org/10.1111/2047-3095.12065

Substance Abuse and Mental Health Services Administration. (2019). *Key substance use and mental health indicators in the United States: Results from the 2018 National Survey on Drug Use and Health* (HHS Publication No. PEP19-5068, NSDUH Series H-54). Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration. https://www.samhsa.gov/data/

Tajik, M., Galvão, H. M., & Eduardo Siqueira, C. (2010). Health survey instrument development through a community-based participatory research approach: Health Promoting Lifestyle Profile (HPLP-II) and Brazilian immigrants in Greater Boston. *Journal of Immigrant and Minority Health*, *12*(3), 390–397. https://doi.org/10.1007/s10903-008-9209-4

The US Burden of Disease Collaborators. (2018). The State of US Health, 1990-2016: Burden of diseases, injuries, and risk factors among US states. *JAMA*, *319*(14), 1444–1472. https://doi.org/10.1001/jama.2018.0158

Timonen, M., Miettunen, J., Hakko, H., Zitting, P., Veijola, J., von Wendt, L., & Räsänen, P. (2002). The association of preceding traumatic brain injury with mental disorders, alcoholism and criminality: The Northern Finland 1966 *Birth Cohort Study*. *Psychiatry Research*, *113*(3), 217–226. https://doi.org/10.1016/S0165-1781(02)00269-X

Tweedly, L., Ponsford, J., & Lee, N. (2012). Investigation of the effectiveness of brief interventions to reduce alcohol consumption following traumatic brain injury. *The Journal of Head Trauma Rehabilitation*, *27*(5), 331–341. https://doi.org/10.1097/HTR.0b013e318262200a

Unsworth, D. J., & Mathias, J. L. (2017). Traumatic brain injury and alcohol/substance abuse: A Bayesian meta-analysis comparing the outcomes of people with and without a history of abuse. *Journal of Clinical and Experimental Neuropsychology*, *39*(6), 547–562. https://doi.org/10.1080/13803395.2016.1248812

Walker, S. N., Sechrist, K. R., & Pender, N. J. (1987). The Health-Promoting Lifestyle Profile: Development and psychometric characteristics. *Nursing Research*, *36*(2), 76–81. https://doi.org/10.1097/00006199-198703000-00002

Weil, Z. M., Corrigan, J. D., & Karelina, K. (2016). Alcohol abuse after traumatic brain injury: Experimental and clinical evidence. *Neuroscience and Biobehavioral Reviews*, *62*, 89–99. https://doi.org/10.1016/j.neubiorev.2016.01.005

Williams, S., Brown, A., Patton, R., Crawford, M. J., & Touquet, R. (2005). The half-life of the "teachable moment" for alcohol misusing patients in the emergency department. *Drug and Alcohol Dependence*, *77*(2), 205–208. https://doi.org/10.1016/j.drugalcdep.2004.07.011

Zatzick, D., Donovan, D. M., Jurkovich, G., Gentilello, L., Dunn, C., Russo, J., Wang, J., Zatzick, C. D., Love, J., McFadden, C., & Rivara, F. P. (2014). Disseminating alcohol screening and brief intervention at trauma centers: A policy-relevant cluster randomized effectiveness trial. *Addiction*, *109*(5), 754–765. https://doi.org/10.1111/add.12492

Received December 30, 2020
Revision received June 6, 2021
Accepted June 11, 2021 ■