ERABI EVIDENCE-BASED REVIEW of moderate to severe ACQUIRED BRAIN INJURY

COMMUNITY REINTEGRATION

POST ACQUIRED BRAIN INJURY

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Disclaimer

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Conflict of Interest

In the context of ERABI development, the term “conflict of interest” (COI) refers to situations in which an author or ERABI staff member’s financial, professional, intellectual, personal, organizational or other relationships may compromise their ability to independently conduct this evidence-based review. No limiting conflicts were identified.

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Greetings from Dr. Robert Teasell,

Professor and Chair-Chief of Physical Medicine and Rehabilitation

The Collaboration of Rehabilitation Research Evidence (CORRE) team is delighted to present the Evidence-Based Review of Moderate to Severe Acquired Brain Injury (ERABI) *Community Reintegration post Acquired Brain Injury.* Through the collaboration of researchers and clinicians and supported by the Ontario Neurotrauma Foundation/Ontario Ministry of Health, ERABI provides an up-to-date review of the current evidence in brain injury rehabilitation. ERABI synthesizes the research literature into a utilizable format, laying the foundation for effective knowledge transfer to improve healthcare programs and services.

We offer our heartfelt thanks to the many stakeholders who are able to make our vision a reality. Firstly, we would like to thank the Ontario Neurotrauma Foundation, which recognizes ERABI's capacity to lead in the field of brain injury evidence-based reviews and has been committed to funding it. We would also like to thank the co-chairs of ERABI, Dr. Mark Bayley (University of Toronto), Dr. Shawn Marshall (University of Ottawa) and Dr. Nora Cullen (MacMaster University) for their invaluable expertise and stewardship of this review. Special thanks to the authors for generously providing their time, knowledge and perspectives to deliver a rigorous and robust review that will guide research, education and practice for a variety of healthcare professionals. We couldn't have done it without you! Together, we are building a culture of evidence-based practice that benefits everyone.

We invite you to share this evidence-based review with your colleagues, patient advisors that are partnering within organizations, and with the government agencies with which you work. We have much to learn from one another. Together, we must ensure that patients with brain injuries receive the best possible care every time they require rehabilitative care – making them the real winners of this great effort!

Robert Teasell, MD FRCPC

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Preface

About the Authors

ERABI is internationally recognized and led by a team of clinicians and researchers with the goal of improving patient outcomes through research evidence. Each ERABI module is developed through the collaboration of many healthcare professionals and researchers.

Cecilia Flores-Sandoval, PhD, is the research coordinator of the Evidence-Based Review of Acquired Brain Injury (ERABI). She completed a master's degree and a PhD in Health and Rehabilitation Sciences, field of Health and Aging. Her research interests include aging and rehabilitation, patient engagement and transitional care for older adults.

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Amber Harnett, MSc, RN, CNF scholar, completed her MSc in pathology at Western University and the accelerated BScN program at Western University. Passionate about supporting and advocating for those with brain injuries, she also works as a research coordinator to improve the rehabilitation system through research synthesis, guideline development, knowledge translation, education and outreach, in the CORRE lab at Parkwood Institute.

Dr. Shawn Marshall is a physician specializing in Physical Medicine and Rehabilitation (Physiatrist). He is the Division Head of Physical Medicine and Rehabilitation at the University of Ottawa and The Ottawa Hospital where he manages both in-patients and out-patient clinics for patients with concussion to severe traumatic brain injury. Dr. Marshall has a Master's degree in Clinical Epidemiology and is a Full Professor at the University of Ottawa in the Department of Medicine.

Dr. Robert Teasell is Professor of Physical Medicine and Rehabilitation, Schulich School of Medicine and Dentistry, Western University and a Clinical Researcher at Lawson Research Institute in London, Ontario. He is a clinician at Parkwood Institute, St. Joseph's Health Care London.

Purpose

The Evidence-Based Review of Acquired Brain Injury (ERABI) is a systematic review of the rehabilitation literature of moderate to severe acquired brain injuries (ABI). It is an annually updated, freely accessible online resource that provides level of evidence statements regarding the strength of various rehabilitation interventions based on research studies. The ERABI is a collaboration of researchers in London, Toronto and Ottawa. Our mission is to improve outcomes and efficiencies of the rehabilitation system through research synthesis, as well as from providing the foundational research evidence for guideline development, knowledge translation, and education initiatives to maximize the real-world applications of rehabilitation research evidence.

Key Concepts

Acquired Brain Injury

For the purposes of this evidence-based review, we used the definition of ABI employed by the Toronto Acquired Brain Injury Network (2005). ABI is defined as damage to the brain that occurs after birth and is not related to congenital disorders, developmental disabilities, or processes that progressively damage the brain. ABI is an umbrella term that encompasses traumatic and non-traumatic etiologies.

TABLE 1 | Defining Acquired Brain Injury

Included in ABI definition	Excluded from ABI definition
Traumatic Causes • Motor vehicle accidents • Falls • Assaults • Gunshot wounds • Sport Injuries **Non-traumatic Causes** • Tumours (benign/meningioma only) • Anoxia • Subarachnoid hemorrhage (non-focal) • Meningitis • Encephalitis/encephalopathy (viral, bacterial, drug, hepatic) • Subdural Hematoma	**Vascular and Pathological Incidents** • Intracerebral hemorrhage (focal) • Cerebrovascular accident (i.e., stroke) • Vascular accidents • Malignant/metastatic tumours **Congenital and Developmental Problems** • Cerebral Palsy • Autism • Developmental delay • Down's syndrome • Spina bifida with hydrocephalus **Progressive Processes** • Alzheimer's disease • Pick's disease • Dementia • Amyotrophic Lateral Sclerosis • Multiple Sclerosis • Parkinson's disease • Huntington's disease

Given that 'ABI' can have multiple definitions, studies with an 'ABI' population can be equally heterogeneous in terms of the sample composition. Such studies may include any combination of persons with TBI, diffuse cerebrovascular events (i.e., subarachnoid hemorrhage) or diffuse infectious disorders (i.e., encephalitis or meningitis). The vast majority of individuals with ABI have a traumatic etiology; therefore, much of the brain injury literature is specific to TBI. The terms ABI and TBI have been used intentionally throughout ERABI to provide more information about populations where relevant.

Moderate to Severe Brain Injury

ABI severity is usually classified according to the level of altered consciousness experienced by the patient following injury (Table 2). The use of level of consciousness as a measurement arose because the primary outcome to understand the severity of an injury is the Glasgow Coma Scale. Consciousness levels following ABI can range from transient disorientation to deep coma. Patients are classified as having a mild, moderate, or severe ABI according to their level of consciousness at the time of initial assessment. Various measures of altered consciousness are used in practice to determine injury severity. Common measures include the Glasgow Coma Scale (GCS), the duration of loss of consciousness (LOC), and the duration of post-traumatic amnesia (PTA). Another factor used to distinguish moderate and severe brain injury is evidence of intracranial injury on conventional brain imaging techniques which distinguish severity of injury from a mild or concussion related brain injury.

TABLE 2 | Defining Severity of Traumatic Brain Injury, adapted from Veterans Affairs Taskforce (2008) and Campbell (2000)

Criteria	Mild	Moderate	Severe	Very Severe
Initial GCS	13-15	9-12	3-8	Not defined
Duration LOC	< 15minutes*	<6 hours	6-48 hours	>48 hours
Duration PTA	< 1hour*	1-24 hours	1-7 days	>7 days
	*This is the upper limit for mild traumatic brain injury; the lower limit is any alteration in mental status (dazed, confused, etc.).			

Methods

An extensive literature search using multiple databases (CINAHL, PubMed/MEDLINE, Scopus, EMBASE, and PsycINFO) was conducted for articles published in the English language up to November 2022 that evaluate the effectiveness of any intervention/treatment related to ABI. The references from key review articles, meta-analyses, and systematic reviews were reviewed to ensure no articles had been overlooked. For certain modules that lacked research evidence the gray literature, as well as additional databases, were searched in order to ensure the topic was covered as comprehensively as possible.

Specific subject headings related to ABI were used as the search terms for each database. The search was broadened by using each specific database's subject headings, this allowed for all other terms in the

database's subject heading hierarchy related to ABI to also be included. The consistent search terms used were "head injur*", "brain injur*", and "traumatic brain injur*". Additional keywords were used specific to each module. A medical staff librarian was consulted to ensure the searches were as comprehensive as possible.

Every effort was made to identify all relevant articles that evaluated rehabilitation interventions/ treatments, with no restrictions as to the stage of recovery or the outcome assessed. For each module, the individual database searches were pooled, and all duplicate references were removed. Each article title/abstract was then reviewed; titles that appeared to involve ABI and a treatment/intervention were selected. The remaining articles were reviewed in full.

Studies meeting the following criteria were included: (1) published in the English language, (2) at least 50% of the study population included participants with ABI (as defined in Table 1) or the study independently reported on a subset of participants with ABI, (3) at least three participants, (4) ≥50% participants had a moderate to severe brain injury (as defined in Table 2), and (5) involved the evaluation of a treatment/intervention with a measurable outcome. Both prospective and retrospective studies were considered. Articles that did not meet our definition of ABI were excluded.

Interpretation of the Evidence

The levels of evidence (Table 3) used to summarize the findings are based on the levels of evidence developed by Sackett et al. (2000). The levels proposed by Sackett et al. (2000) have been modified; specifically, the original ten categories have been reduced to five levels. Level 1 evidence pertains to high quality randomized controlled trials (RCTs) (PEDro ≥6) and has been divided into two subcategories, level 1a and level 1b, based on whether there was one, or more than one, RCT supporting the evidence statement.

The evidence statements made in evidence-based reviews are based on the treatment of groups rather than individuals. There are times when the evidence will not apply to a specific case; however, the majority of patients should be managed according to the evidence. Ultimately, the healthcare professional providing care should determine whether an intervention is appropriate and the intensity with which it should be provided, based on their individual patient's needs. Furthermore, readers are asked to interpret the findings of studies with caution as evidence can be misinterpreted. The most common scenario occurs when results of a trial are generalized to a wider group than the evidence allows. Evidence is a tool, and as such, the interpretation and implementation of it must always be done with the known limitations in mind.

TABLE 3 | Levels of Evidence

Level	Research Design	Description
1A	Randomized Controlled Trial (RCT)	More than one RCT with PEDro score ≥6. Includes within subject comparisons, with randomized conditions and crossover designs
1B	RCT	One RCT with PEDro ≥6
2	RCT	One RCT with PEDro <6
	Prospective Controlled Trial (PCT)	Prospective controlled trial (not randomized)
	Cohort	Prospective longitudinal study using at least two similar groups with one exposed to a particular condition
3	Case Control	A retrospective study comparing conditions including historical controls
4	Pre-Post Trial	A prospective trial with a baseline measure, intervention, and a post-test using a single group of subjects
	Post-test	A prospective intervention study using a post intervention measure only (no pre-test or baseline measurement) with one or more groups
	Case Series	A retrospective study usually collecting variables from a chart review
5	Observational study	Using cross sectional analysis to interpret relations
	Clinical Consensus	Expert opinion without explicit critical appraisal, or based on physiology, biomechanics or “first principles”
	Case Reports	Pre-post or case series involving one subject

Strength of the Evidence

The methodological quality of each randomized controlled trial (RCT) was assessed using the Physiotherapy Evidence Database (PEDro) rating scale developed by the Centre for Evidence-Based Physiotherapy in Australia (Moseley et al., 2002). The PEDro is an 11-item scale; a point is awarded for ten satisfied criterion yielding a score out of ten. The first criterion relates to external validity, with the remaining ten items relating to the internal validity of the clinical trial. The first criterion, eligibility criteria, is not included in the final score. A higher score is representative of a study with higher methodological quality.

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Summary of the Evidence

Intervention	Key Point Level of Evidence
Independence and Social Integration	
Group-Based Interventions	Group-based interventions may improve social integration and self-advocacy in individuals with ABI. - *There is level 1b evidence (Hawley et al., 2022) that a Self-Advocacy for Independent Life (SAIL) intervention may improve self-advocacy and self-efficacy in individuals with TBI; however, it may not improve participation.* - *There is level 2 evidence (Tate et al., 2020) that a program for engagement, participation and activities (PEPA) may improve lifestyle and leisure among individuals with severe TBI; however, further research is needed.* - *There is level 2 evidence (Bulinski, 2010) that a social support program ("Academy of life") focusing on reducing social isolation and improving family bonds may result in higher levels of reported social support and reduced social isolation in individuals with TBI.* Peer-led programs may improve social communication in individuals with ABI. - *There is level 1b evidence (Howell et al., 2021) that a peer-led social communication skills intervention may facilitate response to shared content during social interactions among individuals with ABI.*
Occupational Therapy Interventions	Occupational therapy-based interventions may improve independent living and social participation in individuals with ABI. - *There is level 1b evidence (Dawson et al., 2013) that an occupational-based meta-cognitive strategy training program may improve problem-solving and participation levels in individuals with TBI.* - *There is level 2 evidence (Sloan et al., 2012) that a community participation program delivered with occupational therapy, in both home-like settings and disability-specific settings, may increase the level of independence of individuals with severe ABI.* - *There is level 2 evidence (Sloan et al., 2009b) and level 4 evidence (Sloan et al., 2009b; Trombly et al., 1998) that community-based occupational therapy interventions may reduce support needs and improve functional independence, role participation, and community integration in individuals with severe ABI.*
Speech Therapy	Quasi-contextualized speech therapy may improve community participation among individuals who have sustained a TBI.

	- *There is level 4 evidence (Beaulieu et al., 2021) that a quasi-contextualized speech therapy intervention may improve self-reported community participation and functional independence post TBI.*
Cognitive Interventions	Intensive cognitive rehabilitation may improve community integration in individuals with ABI, when compared to standard neurorehabilitation. - *There is level 2 evidence (Cicerone et al., 2004) that intensive cognitive rehabilitation may improve community integration and neuropsychological functioning compared to standard neurorehabilitation in individuals with TBI.* The use of micro-prompting software and personal digital assistant devices may improve independence; however, computer-based cognitive rehabilitation may not be superior to standard face-to-face rehabilitation. - *There is level 1b evidence (O'Neill et al., 2018) that an audio-verbal interactive micro-prompting system may reduce the number of support-staff prompts needed for the individual to complete activities of daily living post ABI.* - *There is level 3 evidence (Schoenberg et al., 2018) that computer-based cognitive rehabilitation programs and face-to-face cognitive rehabilitation programs may be equally effective in improving independence in individuals with TBI.* - *There is level 4 evidence (Gentry et al., 2008) that the use of a personal digital assistants may improve measures of cognitive and occupational independence, as well as mobility in individuals with TBI.* Self-awareness training may not improve community integration in individuals with ABI. - *There is level 1b evidence (Shum et al. 2011) that compensatory memory strategies, self-awareness training, and participation in memory group sessions may not improve community integration in individuals with TBI.* - *There is level 1b evidence (Goverover et al., 2007) that self-awareness training may not improve community integration compared to conventional therapy in individuals post ABI.* Communication skills training may improve social interactions post TBI. - *There is level 1b evidence (Dahlberg et al., 2007) communication skills training may facilitate communication in individuals with TBI when engaging in social interactions.*
Behavioural Interventions	Behavioral interventions may improve behaviours related to activities of daily living and behaviours within the family unit; however, they may not improve community participation. - *There is level 1b evidence (Ponsford et al., 2022) that a positive behavioral support intervention (PBS+PLUS) intervention may not improve community participation in individuals with ABI.*

	- *There is level 4 evidence (Giles et al., 1997) that a behavioural retraining program may improve behaviours related to activities of daily living.* - *There is 4 evidence (Carnevale, 1996) that a Natural-setting Behavior Management Program (NSBM) may improve challenging behaviours, such as verbal and physical aggression, in family units caring for an individual with ABI.*
Peer Mentorship	Peer mentorship may not improve community integration in individuals with TBI. - *There is level 2 evidence (Hanks et al., 2012; Struchen et al., 2011) that peer mentoring may not improve community or social integration compared to no peer mentorship in individuals post TBI.*
Counseling	Telephone-based counseling may not improve community integration in individuals with TBI. - *There is level 2 evidence (Bell et al., 2011) that telephone-based counseling may not improve independence and social integration, compared to usual care in individuals post TBI.*
Community Rehabilitation	Living in a transitional living unit may improve social integration in individuals post ABI, while community-based rehabilitation while living at home may facilitate performance in activities of daily living. - *There is level 2 evidence (Hopman et al., 2012) that living in a transitional living unit may improve social integration compared to community-based rehabilitation in individuals post ABI; however, both living settings may improve performance of instrumental activities of daily living and social participation.* Community-based life skills intensive training and brain injury drop-in centres in the community that address leisure and social activities may improve community integration and participation in individuals with TBI. - *There is level 2 evidence (Wheeler et al., 2007) that intensive community-based life skills training may improve community integration in post TBI.* - *There is level 3 evidence (McLean et al., 2012) that attending a brain injury drop-in centre in the community may improve social participation in individuals with TBI.*
Multimodal Interventions	Rehabilitation programs delivered by multidisciplinary teams may improve performance in activities of daily living, independence and community integration in individuals with ABI. - *There is level 2 evidence (Powell et al., 2002) that rehabilitation program delivered by a multidisciplinary team may improve performance on activities of daily living and community functioning compared to an information booklet in individuals post severe TBI.*

	- *There is level 2 evidence (Borg et al., 2020) that an interdisciplinary rehabilitation intervention may improve participation and living skills in individuals with ABI.* - *There is level 4 evidence (Perumparaichallai et al., 2020) that a holistic milieu-oriented neurorehabilitation program delivered by a multidisciplinary team may improve community integration in individuals with ABI.* - *There is level 4 evidence (Geurtsen et al., 2011; Geurtsen et al., 2012) that a community reintegration program delivered by a multidisciplinary team may improve independence and social participation post ABI.* - *There is level 4 evidence (Malec, 2001) that a comprehensive multidisciplinary day program incorporating daily group sessions and a transdisciplinary approach may improve independence and participation in individuals with ABI.* - *There is level 4 evidence (Lippert-Gruner et al., 2002) that early-onset multimodal rehabilitation therapy may improve independence in individuals with severe TBI.*
Life Satisfaction and Quality of Life	
Interventions for Life Satisfaction and Quality of Life	Orem's nursing rehabilitation, a resilience intervention, and a structured residential program may improve quality of life post TBI. - *There is level 1b evidence (Assonov, 2021) that a resilience intervention may improve quality of life post TBI, compared to usual care.* - *There is level 2 evidence (Yang et al., 2022) that a nursing rehabilitation model based on Orem's self-care theory may improve quality of life in individuals with TBI.* - *There is level 4 evidence (Geurtsen et al., 2011; Geurtsen et al., 2012) that a structured residential treatment program may improve quality of life in individuals with ABI.* A Medicaid program may not improve quality of life post TBI, when compared to no service. - *There is level 3 evidence (Cusick et al., 2003) that the Colorado Medicaid Program may not improve life satisfaction in individuals with TBI.*
Social Support Groups	Social supports groups may decrease feelings of hopelessness and increase quality of life among those with moderate to severe TBI. - *There is level 4 evidence (Vandiver & Christofero-Snider, 2000) that social support groups may increase self-efficacy and quality of life as well as decrease feelings of hopelessness in individuals post TBI.*
Leisure Education Programs	Leisure education programs may improve quality of life post ABI, as well as leisure satisfaction, self-esteem, and general well-being.

	- *There is level 4 evidence (Carbonneau et al., 2011; Mitchell et al., 2014) that leisure education programs may improve leisure satisfaction, self-esteem, well-being, and quality of life in individuals with moderate to severe ABI.*
Physical Therapy	Dance rehabilitation may not improve quality of life post TBI. Ballistic exercise training may not improve quality of life in individuals with TBI, when compared to non-ballistic exercise. A yoga intervention may improve quality of life post ABI, particularly for younger individuals. - *There is 1a evidence (Sarkamo et al., 2021) that dance rehabilitation may not improve quality of life in individuals with moderate to severe TBI.* - *There is 1b evidence (Williams et al., 2022) that ballistic exercise training may not improve quality of life in individuals with TBI.* - *There is level 4 evidence (Donnelly et al., 2021) that a yoga intervention may improve quality of life post ABI, particularly for younger people.*
Music Therapy	Music therapy may not improve quality of life post TBI. - *There is 2 evidence (Siponkoski et al., 2022) that neurological music therapy may not improve quality of life in individuals who have sustained a moderate to severe TBI.*
Cognitive Interventions	Cognitive interventions may improve quality of life and community integration in individuals with moderate to severe TBI. - *There is level 1b evidence (Cicerone et al., 2008) that an intensive cognitive rehabilitation program may improve community integration and perceived quality of life compared to standard neurorehabilitation in individuals with TBI.* - *There is level 4 evidence (Afsar et al., 2021) that a cognitive retraining (CR) intervention may improve quality of life in individuals with severe TBI.*
Technology Interventions	The use of remote web-based resources or virtual reality platforms for the delivery of rehabilitation may not improve quality of life, when compared to usual care post moderate to severe TBI. Assistance from a humanoid robot in the delivery od neurorehabilitation to individuals with ABI may improve quality of life. - *There is level 1b evidence (Bergquist et al., 2022) that a web-based community resource (Care Hubs) may not improve perceived quality of life in individuals with TBI, when compared to usual care.* - *There is level 1b evidence (Corallo et al., 2022) that assistance of a humanoid robot in the delivery of neurorehabilitation may improve quality of life post ABI.* - *There is level 1b evidence (Mendes et al., 2021) that remote holistic neuropsychological program by a VR platform may not be effective for improving quality of life and psychosocial function.*

Vocational Rehabilitation and Productivity	
Cognitive Interventions	Cognitive rehabilitation therapy may not be effective for improving employment rates in individuals with TBI. - *There is level 1b evidence (Vanderploeg et al., 2008) that cognitive-didactic therapy may not be more effective than functional-experiential rehabilitation therapy for facilitating return to work in individuals post TBI.* - *There is 1b level of evidence (Cicerone et al., 2008) that a holistic cognitive rehabilitation program may improve employment rate among individuals with TBI.* - *There is level 1b evidence (Salazar et al., 2000) that intensive hospital-based cognitive rehabilitation may not improve return to work compared to limited home-based rehabilitation in individuals post TBI.* - *There is level 2 evidence (Man et al., 2013) that artificial intelligence virtual reality problem-solving training may not improve employment outcomes compared to a conventional psychoeducational program in individuals post TBI.* - *There is level 3 evidence (Schoenberg et al., 2018) that computer-based cognitive rehabilitation programs and face-to-face cognitive rehabilitation programs may be equally effective in improving return to work and/or school in individuals with moderate-to-severe TBI.*
Educational Interventions	Simulated educational experiences may be helpful for predicting an individual's readiness to return to school post ABI. - *There is level 4 evidence (MacLennan & MacLennan, 2008) that a simulated college experience may predict readiness for post-secondary education in individuals post TBI.*
Mentorship Programs	Mentorship in the community or at the workplace may be effective for improving employment and education rates post ABI. - *There is level 4 evidence (Curl et al., 1996) that a model where coworkers act as trainers in the work environment may improve vocational outcomes in individuals with severe TBI.*
Community-based Rehabilitation	Community-based vocational rehabilitation may improve employment outcomes post ABI. - *There is level 4 evidence (Malec & Moessner, 2000; Wall et al., 1998) that community-based programs may improve return to work in individuals post ABI.* - *There is level 4 evidence (Buffington & Malec, 1997; Klonoff et al. 2001) that vocational services and work/school re-entry programs may improve vocational outcomes in individuals with TBI.* - *There is level 4 evidence (Wehman, Kreutzer, et al., 1989; Wehman et al., 1993; Wehman, West, et al., 1989b; Wehman et al., 1988) that supported employment interventions may improve vocational outcomes in individuals with severe TBI.*

Resource Facilitation	Resource facilitation may improve employment rates post TBI. - *There is level 2 evidence (Trexler & Parrott, 2018) that connecting patients and caregivers with community-based resources and services may improve vocational outcomes in individuals post TBI.* - *There is level 2 evidence (Radford et al., 2013) that a resource facilitator may improve return to work compared to standard care in individuals with TBI.*
Technology Interventions	Virtual reality training may not be more effective than conventional psychoeducation in improving employment outcomes post TBI. - *There is level 2 evidence (Man et al., 2013) that artificial intelligence virtual reality training may not improve employment outcomes compared to a conventional psychoeducational program in individuals post TBI.*
Multimodal Interventions	Various multimodal interventions may improve return to work and school post ABI. While multimodal programs are heterogenous and present different approaches, interventions that address independence, social awareness and neuropsychological rehabilitation may result in greater vocational improvements. - *There is level 2 evidence (Cogne et al., 2017) that the Evaluation, Retraining, Social, and Vocational Unit (UEROS) program may improve return to work outcomes in individuals post ABI.* - *There is level 2 evidence (Watanabe, 2013; Walker et al., 2006) that inpatient rehabilitation may improve return to work in individuals post TBI. However, the benefits of post-acute neurorehabilitation services may not be maintained at 7 years (Twomey et al., 2021).* - *There is level 2 evidence (Shany-Ur et al., 2020) that a comprehensive-holistic neuropsychological program, a vocational-focused and an individual neuropsychological may improve work stability post ABI across time.* - *There is level 2 evidence (Malec & Degiorgio, 2002) that specialized vocational services alone may not be less effective than specialized vocational services paired with either community reintegration or comprehensive day treatment for facilitating return to work in individuals post ABI.* - *There is level 2 evidence (Haffey et al., 1991) that a work re-entry program may improve return to work outcomes in individuals with moderate to severe TBI.* - *There is level 3 evidence (O'Neill et al., 2004) that the Program Without Walls may improve employment rates and incomes compared to traditional vocational rehabilitation in individuals post ABI with no associated increase in the cost of case management services.* - *There is level 4 evidence (Perumparaichallai et al., 2020) that a holistic milieu-oriented neurorehabilitation intervention may improve productivity in individuals with ABI.* - *There is level 4 evidence (Rumrill et al., 2019) that an individualized support program involving cognitive support technology and vocational rehabilitation interventions may increase job readiness and career prospects in undergraduate students with TBI.*

	- *There is level 4 evidence (De Kort et al., 2002) that the Come Back Program may improve independent living and return to work post ABI.* - *There is level 4 evidence (Geurtsen et al., 2008; Geurtsen et al., 2011; Geurtsen et al., 2012) that a structured residential community reintegration program may improve and employability post ABI.* - *There is level 4 evidence (Bonneterre et al., 2013) that the personalized service of accompaniment and follow-up to employment (SPASE) program may improve workplace reintegration post TBI.* - *There is level 4 evidence from one case series (Foy, 2014) an integrated intensive residential neurological and vocational rehabilitation program may improve vocational outcomes in individuals post severe ABI.* - *There is level 4 evidence (Malec, 2001) that a comprehensive day treatment program incorporating daily group sessions and a transdisciplinary approach may improve vocational outcomes in individuals post ABI.* - *There is level 4 evidence (Malec et al., 1995) that integrative medical center- and community-based services specifically targeting barriers to employment may improve vocational outcomes in individuals with severe TBI.*
Return to Driving	
Interventions for Return to Driving	Multidisciplinary neurorehabilitation and on-road training lessons may help individuals to return to driving post moderate to severe ABI. - *There is level 2 evidence (Kewman et al., 1985) that simulation training of psychomotor skills may improve the ability to drive in individuals with severe ABI.* - *There is level 2 evidence (Ross et al., 2018) that on-road training lessons addressing individual goals may improve return to driving in individuals with ABI who failed an initial on-road driving test.* - *There is level 4 evidence (Perumparaichallai et al., 2014; Leon-Carrion et al., 2005) that multidisciplinary neurorehabilitation may improve return to driving in individuals post ABI.* - *There is level 4 evidence (Perumparaichallai et al., 2020) that holistic milieu-oriented neurorehabilitation interventions may improve return to driving in individuals with ABI.* - *There is level 4 evidence (De Tanti et al., 2020) that individuals with ABI may require vehicle assistive devices to safely return to driving.*
Caregiving and Caregiver Burden	
Social Support Groups	Social support groups, delivered via video or telephone, as well as problem-solving interventions may improve outcomes in caregivers of individuals who sustained a moderate to severe ABI. - *There is level 2 evidence (Rivera et al, 2008) that problem-solving therapy may improve depression, health complaints, and dysfunctional problem solving, but not well-being or burden, compared to an educational program in caregivers of individuals with ABI.*

	- *There is level 2 evidence (Brown et al., 1999) that telephone support groups may reduce burden and distress compared to traditional face-to-face on-site support groups in caregivers of individuals with ABI.* - *There is level 2 evidence (Niemeier et al., 2018) that a manualized caregiver intervention with educational, self-management, coping, and emotional support components may reduce emotional burden and improve brain injury knowledge in caregivers of individuals with moderate to severe TBI.* - *There is level 4 evidence (Acorn, 1995) that on-site support groups may not improve well-being, life satisfaction or self-esteem in caregivers of individuals with head injury. However, these groups may improve the use of supportive coping styles.*
Educational Interventions	Educational interventions may improve outcomes for caregivers of individuals with moderate to severe TBI, including psychological health, coping, problem-solving and emotional burden. - *There is 1b evidence (Brown et al., 2015) that curriculum-based advocacy training was not superior to a self-directed approach in improving advocacy behavior in individuals with moderate to severe TBI and their caregivers.* - *There is level 2 evidence (Sinnakaruppan et al., 2005) that educational training programs may reduce depression among caregivers of individuals post ABI. However, this result needs to be interpreted with caution as it was not demonstrated consistently across all measures of depression that were reported by the study.* - *There is level 2 evidence (Carnevale et al., 2002) that providing education to a caregiver as well as behavior management for the individual with an ABI may not be more effective for improving family stress or burnout risk compared to education alone.* - *There is level 4 evidence (Geurtsen et al., 2011) that the provision of education and counselling may reduce emotional burden and improve psychological health in caregivers of individuals with chronic ABI.* - *There is level 4 evidence (Sander et al., 2009) that web-based videoconference education interventions may improve coping and problem-solving in caregivers of individuals with TBI.*
Psychotherapy	Group Acceptance and Commitment Therapy (ACT) may improve symptoms of anxiety and increase family function for caregivers of individuals post severe TBI. - *There is level 1b evidence (Hadavand et al., 2022) that group acceptance and commitment therapy (ACT) may help relieve anxiety and improve family function in caregivers of individuals with severe TBI.*
Multimodal Interventions	Multimodal interventions that are offered to families of individuals with moderate to severe ABI may result in improved social integration and reduced caregiver burden. - *There is level 1b evidence (Powell et al., 2016) that a telephone delivered intervention after discharge may improve emotional wellbeing in caregivers of individuals with TBI.*

- *There is level 2 evidence (Kreutzer et al., 2010; Kreutzer et al., 2015) that a structured family intervention program with educational, skill building, and psychological support components may improve goal attainment in individuals with moderate to severe ABI and their caregivers.*

- *There is level 3 evidence (Smith et al., 2006) that community-based rehabilitation for the individual with an ABI may be more effective than traditional outpatient services in benefiting caregivers of individuals post ABI by improving levels of met family needs and reducing family dysfunction.*

- *There is level 4 evidence (Kreutzer et al., 2009) that the Brain Injury Family Intervention may improve met family needs and satisfaction with services and reduce burden in caregivers of individuals with TBI.*

- *There is level 4 evidence (Gerber & Gargaro, 2015) that a multifaceted day program for individuals with TBI and their caregivers may improve social integration and caregiver burden.*

Introduction

Community reintegration is considered the ultimate goal of acquired brain injury (ABI) rehabilitation; however, this process is complex and multifaceted, and often a challenging hurdle for both patients and their caregivers (McCabe et al., 2007). Community integration involves the participation in community activities such as engaging in a productive activity, establishing interpersonal relationships and living independently (Shaikh et al., 2019). For instance, engaging in activities of daily living (e.g., grocery shopping), leisure activities (e.g., sports, cinema), social activities (e.g., eating with friends), and activities outside of the home (e.g., school, work, volunteering) (Kersey et al., 2019).

When individuals with ABI transition back into the community from acute care or post-acute rehabilitation, they require diverse supports, often for extended periods of time, to successfully reintegrate into their communities (McCabe et al., 2007). Rehabilitation interventions for community reintegration primarily focus on restoring independence while addressing the unique needs from different age groups. For instance, older adults may have different needs than younger age groups, as they are less likely to return to work and may encounter barriers for social participation, as well as for social support (Ritchie et al., 2014). For younger adults, who are more likely to return to work after sustaining an ABI, vocational rehabilitation may facilitate the transition to school, work or volunteer activity. Regardless of age, it is critical to engage the individual in the care plan and to consider their personal goals, needs, values, hopes, cultural context, family situation and social environment (Truelle et al., 2010).

Rehabilitation interventions for community reintegration focus primarily on areas such as independence, social participation, relieving caregiver burden, quality of life and life satisfaction, vocational rehabilitation, and return to driving (McCabe et al., 2007). It should be noted that the evaluation of clinical work in this area may not lend itself well to randomized controlled trials (RCT), due to the individualized nature of community rehabilitation protocols. This module reviews the available evidence pertaining to community reintegration following ABI and is broken down into sections focusing on interventions targeting either the individual with ABI or the caregiver.

Independence and Social Integration

Establishing independence and strong social networks post ABI can be challenging. It has been reported that a third of individuals who have sustained an ABI are dissatisfied with their level of independence, social lives, and interpersonal relationships (Larsson et al., 2013). Independence is an attribute of community integration post ABI that is related to physical function in activities of daily living inside or outside the home (e.g., household activities, services and venues), as well as to everyday decision-

making and the practice of self-determination (Shaikh et al., 2019). Social integration and connection are also important attributes of community integration, such as visiting friends or shopping; as well as establishing and maintaining interpersonal relationships with other people, such as family members and friends (Shaikh et al., 2019).

The onset of an ABI often leads to reduced independence, which can in turn, negatively impact the ability of the individual to maintain and build social relationships. Social connection and relationship building can also be impacted due to difficulties regulating emotions and behaviour, as well as difficulties understanding social meaning (McDonald & Genova, 2021). Individuals who have sustained an ABI and live with limited independence have reported fewer close relationships and less social contact (Johnson & Davis, 1998). Individuals with ABI also face social isolation and a lack of social support, as well as self-reported lower self-esteem and perceived low sex appeal (Johnson & Davis, 1998; Kreuter et al., 1998; Kreutzer & Zasler, 1989). Difficulties with emotional and behavioural changes may also impact close relationships with partners and spouses may also lead to divorce, with a reported rate of 58% five years post injury (Truelle et al., 2010).

Rehabilitation is important for improving independence and social integration. To address the unique needs of each individual, multiple interventions may be required to be provided in combination. Individuals who engage in rehabilitation, whether it is community-based, in-home care, or a residential transitional living program, have been found to experience improvements in productivity, social integration, and activities of daily living (ADLs) (Hopman et al., 2012).

Group-Based Interventions

Group-based interventions provide an opportunity for individuals to undergo rehabilitation while also interacting with others who may have had similar experiences. Social interaction through brain injury support groups can provide individuals with a sense of belonging and reduce feelings of isolation. Social interaction within the treatment group can also help prepare the individual with an ABI for social settings outside of a treatment environment.

TABLE 4| Group-Based Interventions for Independence and Social Integration Post ABI

Author, Year Country Study Design Sample Size	Methods	Outcome
Hawley et al., (2022) Australia RCT PEDro=8 N=67	**Population:** TBI; *SAIL Intervention Group* (n=35); Mean Age=52.8yr; Gender: Males=20, Females= 15; Time Post Injury= Median 9.2yr (IQR 4.7-13.1); *Control group* (n=32); Mean Age=51.1yr; Gender: Male=17, Female=15. **Intervention:** Participants received a group	1. The treatment group showed significantly greater improvement than controls at post treatment (p= .0029), and non-significant improvement at 6-mo (p = .3638), and 12-month follow ups (p = .1375) on the SAS.

Author, Year Country Study Design Sample Size	Methods	Outcome
	intervention, Self-Advocacy for Independent Life (SAIL), addressing the self-efficacy beliefs, knowledge, and skills for self-advocacy following TBI. The duration was 3h/wk for 3 consecutive wk, a 3h/wk session 3 wk later, and a booster calls at wk 8 and 10. The follow-up assessments were at 6 wk and 12 wk. The control group did not receive any intervention. **Outcome Measures:** Self-Advocacy Scale (SAS), General Self-Efficacy Scale (GSE), Personal Advocacy Activity Scale (PAAS), Satisfaction With Life Scale (SWLS), The Flourishing Scale (FS), The Participation Assessment with Recombined Tools Objective (PART-O)	2. There were significant differences in changes in mean GSE scores (p= .0134) and mean SWLS scores (p = .0086) between groups; however, these between-group differences were not statistically significant at 6- and 12-wk follow-up. 3. There were not significant differences in the changes in the PAAS (p = .8246), FS (p = .1085), or PART-O (p = .3754).
Tate et al. (2020) Australia PCT $N_{Initial}$=10, N_{Final}=7	**Population:** Severe TBI; *Functionally independent (n=4)* Gender: Unspecified; *Dependent on caregiver (n=3)* Gender: Unspecified; Mean Age=Unreported; Mean Time Post- Injury=Not reported. **Intervention:** Individuals participated in a program for Engagement, Participation and Activities, (PEPA) for goal-directed non-vocational activity to improve lifestyle domains such as mood and community participation. A total of 17hr face to face sessions of intervention, followed up at 2 and 6 mo. **Outcome Measures:** Goal Attainment Scale (GAS), Nottingham Leisure Questionnaire (NLQ), revised Lubben Social Network Scale, (LSNS-R), Depression, Anxiety and Stress Scales (DASS), Coopersmith Self-Esteem Inventory (CSEI), Satisfaction with Life Scale, (SWLS), Quality of Life after Brain Injury, (QOLIBRI), Social Support Survey (SSS), Community Integration Measure (CIM), World Health Organization Disability Assessment Scale 2.0 (WHODAS-2), Frontal Systems Behavior Scale (FrSBe), Sydney Psychosocial Reintegration Scale (SPRS), Care and Needs Scale (CANS), Goal Commitment Questionnaire, Readiness for Change.	1. Tau-U analyses were also used to determine whether the three domains addressed by the PEPA (leisure, social and lifestyle) showed an experimental effect, for the lifestyle domain five of the seven participants showed very large ES (.92–1.0); for the leisure domain four of the seven had at least a large ES (.6–1.0). 2. The analysis for goal attainment and the analysis for goal commitment were underpowered.
Social Relationships Interventions		
Howell et al., (2021) UK RCT PEDro=8 $N_{initial}$=12, N_{final}=9	**Population:** Severe ABI; TBI=5, Hydrocephalus=2, Encephalitis=1, Hypoxia=2, Intracranial haemorrhage=1, Subarachnoid hemorrhage=1; *Intervention Group* (n=6); Mean Age=45.8yr; Gender: Male=4, Female=2; Time Post Injury Mean= 7.63 yr. *Control Group* (n=6); Mean Age=52yr; Gender: Male=4, Female=2; Injury= Severe (GCS<9); Time Post Injury Mean=1.42yr. **Intervention:** Peer-led social communications skills intervention or usual care for 2x/wk x8wk for a total study duration of 12 wk. The peer was separately trained through 16 sessions over 4wk. Group behaviour was measured twice at baseline, after the	1. The main effects in the analyses were not significant. On the interaction scale, the interaction of group by time from baseline to maintenance was not significant (p = .23). On the transaction scale, the interaction of group by time from baseline to maintenance did not reach significance (p = .1). 2. When the pre and post scores were analyzed, a significant interaction was obtained (p = .02), indicating increased gains over time for the treated group in initiating and responding to shared conversation content as compared to the control group.

Author, Year Country Study Design Sample Size	Methods	Outcome
	intervention and at 4 wk. The control group was a staff led activity care (usual care) group. **Outcome Measures:** Adapted Measure of Participation in Conversation (MPC), Interactional Network Tool (INT), LCQ Questionnaires.	3. There was an increase in mean scores for the intervention group across all time points and a decrease for the control group, indicating an improved ability by members of the intervention group to respond to shared content in conversation. 4. A more balanced distribution of verbal and nonverbal initiations and responses over time by the group members in the intervention group which was facilitated by the peer.
Bulinski (2010) Poland PCT N=200	**Population:** Severe TBI; *Group A* (PTSD+TBI; n=101); Mean Age: Male= 24.10±11.02yr, Female=22.11±4.52yr; Gender: Male=61, Female=40; Time Post Injury=Not reported. *Group B* (TBI only; n=99): Mean Age: Male= 25.10±12.37yr, Female=23.11±7.43yr; Gender: Male=57 Female=42; Mean Time Post Injury=Not Reported. **Intervention**: Participants took part in a social support program "Academy of Life" for 6mo. The program focused on reduction of social isolation and reintegration of the family bond in its cognitive emotional and social aspects, as well as barriers in communication. Outcome measures were assessed pre- and post intervention. **Outcome Measures**: Document analysis, clinical interviews with caregivers, Family Bonds Modification Questionnaire, Social Isolation Scale, "Social Functions" subscale the Evaluation of QOL in TBI patients.	1. After the intervention, there was selective improvement on all parameters, particularly in patients without PTSD symptoms. 2. Desynchronization of cognitive, emotional, and social bonds decreased (p>.05). 3. Participants reported more positive support and less negative support (p<.05), as well as decreased loneliness as a result of social ostracism (p<.05) 4. The best effects were achieved in the reduction of social dysfunctions, growth of purposeful social activity, improvement in type of support received, and reduction of selected parameters of social isolation.

Discussion

In an RCT, Hawley et al. (2022) examined the effectiveness of a group intervention, Self-Advocacy for Independent Life (SAIL), that addressed self-efficacy beliefs, knowledge and skills for self-advocacy. The authors found that the intervention group had greater improvements in self-advocacy, self-efficacy and satisfaction with life, when compared to controls. However, no significant differences were observed on participation. In a small PCT, Tate et al. (2020) examined a program for engagement, participation and activities (PEPA) aimed to improve lifestyle and leisure among individuals with severe TBI. The authors found that five of seven participants improved in social, leisure and lifestyle domains. However, given the small sample and underpowered analyses, the results from this study should be interpreted with caution.

In a PCT study by Bulinski (2010), participants with TBI took part in a social support program "Academy of Life" that focused on reducing social isolation and on the reintegration of the family bond. After the intervention, participants reported less social isolation and increased positive social support; however,

these improvements were less evident in individuals who presented with post-traumatic stress disorder (PTSD). In an RCT, Howell et al. (2021) investigated the effects of a peer-led social communications skills intervention for individuals with ABI, compared to staff led usual care. The authors found that the intervention group presented a more balanced pattern of verbal and non-verbal initiations and responses over time.

Conclusions

There is level 1b evidence (Hawley et al., 2022) that a Self-Advocacy for Independent Life (SAIL) intervention may improve self-advocacy and self-efficacy in individuals with TBI; however, it may not improve participation.

There is level 1b evidence (Howell et al., 2021) that a peer-led social communication skills intervention may facilitate response to shared content during social interactions among individuals with ABI.

There is level 2 evidence (Tate et al., 2020) that a program for engagement, participation and activities (PEPA) may improve lifestyle and leisure among individuals with severe TBI; however, further research is needed.

There is level 2 evidence (Bulinski, 2010) that a social support program ("Academy of life") focusing on reducing social isolation and improving family bonds may result in higher levels of reported social support and reduced social isolation in individuals with TBI.

KEY POINTS

- Group-based interventions may improve social integration and self-advocacy in individuals with ABI.
- Peer-led programs may improve social communication in individuals with ABI.

Occupational Therapy Interventions

Occupational therapy recognizes the importance of meaningful occupations for the physical, mental and social wellbeing of the individual and it aims to help individuals engage in meaningful activities that are important to them in a variety of environments, including at home, work, school or in the community (Bolt et al., 2019). Occupational therapists play an important role in community reintegration for individuals with brain injuries, as they can advocate for their clients to ensure they have fair access to their chosen occupations (King & Curtin, 2014).

TABLE 5| Occupational Therapy Interventions for Independence and Social Integration Post ABI

Author, Year Country Study Design Sample Size	Methods	Outcome
Dawson et al. (2013) Canada RCT PEDro=6 N=13	**Population:** TBI=13; *Experimental group*: Mean Age= 42.6yr; Gender: Male=4, Female=3; Mean Time Post Injury=9.8±6.0yr; Severity: Mild=1, Moderate-to-Severe=6. *Control group*: Mean Age=40.5yr; Gender: Male=3, Female=3; Mean Time Post Injury=10.8±6.0yr; Severity: Mild=1, Moderate-to-Severe=5. **Intervention:** The experimental group received occupation-based strategy training delivered by occupational therapists, which involved a meta-cognitive strategy (goal-plan-do-check) to facilitate problem solving and occupational goal setting. Training was provided in two 1h sessions/wk for 10wk. The control group received no treatment. Outcome measures were assessed before and after the intervention phase. **Outcome Measures:** Canadian Occupational Performance Measure (COPM), Dysexecutive Questionnaire (DEX), Mayo-Portland Adaptability Inventory-4 Participation Index (M2PI), Assessment of Motor and Process Skills (AMPS).	1. The experimental group improved significantly more than the control group on performance (COPM; p=.03) and satisfaction with performance ratings on untrained goals (COPM; p=.04). 2. The experimental group reported increased levels of participation (M2PI; p=.01). 3. No significant difference was observed on measures of executive dysfunction (DEX; p>.05), or motor performance (AMPS; p>.05).
Sloan et al. (2012) Australia Cohort N=43	**Population:** Severe ABI, TBI=29, Hypoxia=9, Cerebrovascular=5; Mean Age=28.42yr; Gender: Male=25, Female=18; Mean Time Post Injury=6.73 yr. **Intervention:** Participants attended the Community Approach to Participation rehabilitation program aimed at maximizing the level of participation in valued life roles. Participants were grouped by home-like (n=28) or disability-specific (n=12) accommodation setting. All participants received occupational therapy. Outcomes were assessed at baseline, 1, 2, and 3 yr. **Outcome Measures:** Care and Needs Scale (CANS), Functional independence Measure (FIM), Community Integration Questionnaire (CIQ), Part One of the Role Checklist (RC), number of hours of gratuitous care.	1. The home-like accommodations group had significant improvement on the CANS (p=0.001), number of hours of gratuitous care per wk (p=0.001), FIM (p=0.03), CIQ and RC (p<0.001) across the 3-yr period. 2. The disability-specific accommodations group had significant improvement on the CIQ (p=0.001) and RC (p=0.02) across the 3-yr period. 3. The disability specific accommodations group, compared to the home-like accommodations group, required a significantly higher level of support (CANS) at all time points (p≤0.003). A significant change in the CANS was only seen in the home-like accommodations group post intervention.
Sloan et al. (2009a) Australia Pre-Post N=43	**Population:** Severe ABI, TBI=67%, Hypoxia=21%, Cerebrovascular accident or infection=12%; Mean Age=Not Reported; Gender: Male=25, Female=18; Mean Time Post Injury=6.73yr. **Intervention:** Participants received a 3yr Community Approach to Participation (CAP) occupational therapy (OT) intervention. The CAP OT is a community-based rehabilitation program aimed at maximizing the level of participation in valued life roles. Outcome measures were assessed at four time points (Baseline), at 1yr (T1), at 2yr (T2), and 3yr (T3).	1. Participants' support needs decreased significantly from Baseline to T1 (CANS; p=.005), and from T1 to T2 (CANS; p=.02). 2. There was a significant decrease in total care hours per week from baseline to T2 (p =.003), from Baseline to T3 (p =.003), and from T1 to T2 (p=.006). 3. The mean hours of gratuitous care per week reduced significantly over the intervention period (p=.02)

Author, Year Country Study Design Sample Size	Methods	Outcome
	Outcome Measures: Care and Needs Scale (CANS); number of hours of paid and gratuitous weekly support; Functional Independence Measure (FIM), Community Integration Questionnaire (CIQ), Role Checklist (RC Part 1)	4. Participants showed a significant improvement in the FIM from Baseline to T1 (p<.001). 5. Participants showed a significant improvement in the CIQ between Baseline and T1 (p<.001) and T1 and T2 (p=.004). 6. Participants showed a significant improvement in the RC Part 1 between Baseline and T1 (p< .001) and between T2 and T3 (p<.02).
Sloan et al. (2009b) Australia PCT N=85	**Population**: Severe ABI; *Early Group (n=26):* Age at Injury= 35.7±18.85yr; Gender: Male=73%, Female=27%; Mean Time Post Injury=343d, Severity: Severe=26; *Late Group* (n=59): Age at Injury= 24.71yr; Gender: Male=56%, Female=44%; Mean Time Post Injury=10.2yr; Severity: Severe=59 **Intervention**: Participants received an average of 51.01hr of CAP OT intervention for up to 12mo. The CAP OT is a community-based rehabilitation program aimed at maximizing the level of participation in valued life roles. Outcome measures were assessed prior to the intervention (Baseline) and after a 12-mo period or at discharge (TI). **Outcome Measures**: Functional Independence Measure (FIM), Community Integration Questionnaire (CIQ), Role Checklist (RC Part 1)	1. Both groups showed a significant improvement in the FIM from Baseline to T1 (p<.001). 2. Both groups showed a significant improvement in the CIQ from Baseline to T1 (p<.001). 3. Both groups showed a significant improvement in the RC Part 1 from Baseline to T1 (p<.001). 4. Participation in the roles of volunteer (RC; p<.05), home maintainer (RC; p<.001), hobbyist (RC; p<.01), and participation in organizations (RC; p<.01) increased significantly for both groups from Baseline to T1.
Trombly et al. (1998) USA Pre-Post N=16	**Population:** TBI; Mean Age=43yr; Gender: Male=9, Female=7; Mean Time Post Injury=22mo. **Intervention:** Participants received occupational therapy to restore independence in the home and community. **Outcome Measures:** Goal Attainment Scale (GAS), Canadian Occupational Performance Measure (COPM), Independent Living Skills Evaluation (ILSE), Reintegration to Normal Living Scale (RNL).	1. Participants significantly achieved their goals (GAS) from admission to discharge and rated themselves as performing significantly better (p<0.001) and were significantly more satisfied with their performance after treatment than beforehand (p=0.001). 2. Additionally, they improved significantly on the COPM, ILSE and RNL (p<0.001 on all). 3. There were no significant changes in performance from discharge to follow-up on any of the scale

Discussion

In an RCT, Dawson et al. (2013) examined the effectiveness of an occupational-based strategy training program for individuals with TBI that involved a meta-cognitive strategy (Goal-Plan-Do-Check) to facilitate problem-solving and goal setting. The authors found that the intervention group showed significant improvements on performance on trained tasks and reported higher participation levels,

when compared to the controls. However, given the small sample size, findings from this study should be interpreted with caution.

In a cohort study, Sloan et al. (2012) examined participation outcomes and living situation of individuals with severe ABI who received occupational therapy and participated in a rehabilitation program (Community Approach Participation). The authors found that both groups (home-like accommodations and disability-specific accommodations) significantly increased their number of life roles over a 3-year period; in addition, participants in home-like settings increase their level of independence and community integration. Similarly, in two earlier studies, a pre-post study and a PCT study, Sloan et al. (2009a, 2009b) reported that group-based occupational therapy in assisted living settings and community environments significantly improved functional independence as well as community integration and led to enhanced participation in valued life roles in individuals with ABI. Similar results reported by Trombly et al. (1998) in a pre-post study.

Conclusions

There is level 1b evidence (Dawson et al., 2013) that an occupational-based meta-cognitive strategy training program may improve problem-solving and participation levels in individuals with TBI.

There is level 2 evidence (Sloan et al., 2012) that a community participation program delivered with occupational therapy, in both home-like settings and disability-specific settings, may increase the level of independence of individuals with severe ABI.

There is level 2 evidence (Sloan et al., 2009b) and level 4 evidence (Sloan et al., 2009b; Trombly et al., 1998) that community-based occupational therapy interventions may reduce support needs and improve functional independence, role participation, and community integration in individuals with severe ABI.

KEY POINTS

- Occupational therapy-based interventions may improve independent living and social participation in individuals with ABI.

Speech Therapy

Speech language pathologists (SLPs) play an important role in the rehabilitation of individuals with brain injuries, across all severities and clinical settings. Assessing the cognitive communication status of individuals with brain injuries is critical to make decisions regarding their discharge plan; including

aspects such as their ability to return to work, live independently and actively participate in their communities (Morrow et al., 2020).

TABLE 6| Speech Therapy for Independence and Social Integration Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Beaulieu et al., (2021) USA Case series N=1760	**Population:** TBI; Gender: Male=72%, Female=28%; Mean Age=44.41yr; Time Post Injury=Not Reported. **Intervention:** Participants received quasi-contextualized speech therapy, defined as metacognitive, compensatory, or strategy training applied to cognitive and language impairments to facilitate the performance of future real-life activities. **Outcome Measures:** Participation Assessment with Recombined Tools-Objective-17 (PART-O-17); Functional Independence Measure (FIM) Motor and Cognitive scores; Satisfaction With Life Scale (SWLS); Patient Health Questionnaire-9.	1. When at least 5% of therapy time employed quasi-contextualized treatment, people with TBI reported better community participation on the PART-O, FIM during the year following discharge. 2. Quasi-contextualized treatment was also associated with better motor and cognitive function at discharge and during the year after discharge.

Discussion

In a case series study, Beaulieu et al. (2021) examined the effect of providing a quasi-contextualized speech therapy to individuals with cognitive and language impairments post TBI. The intervention, defined as metacognitive, compensatory, aimed to facilitate individual's performance in real-life future activities and functional outcomes. The authors found that the intervention was associated with better self-reported community participation during the year following discharge.

Conclusions

There is level 4 evidence (Beaulieu et al., 2021) that a quasi-contextualized speech therapy intervention may improve self-reported community participation and functional independence post TBI.

KEY POINTS

- Quasi-contextualized speech therapy may improve community participation among individuals who have sustained a TBI.

Cognitive Interventions

Presenting with cognitive impairment following ABI can contribute to chronic disability (Cicerone et al., 2004). Cognitive rehabilitation may promote the reduction of functional disability and recovery time in individuals with brain injuries (Barman et al., 2016). Addressing cognitive difficulties may lead to

improvements in areas such as activities of daily living, independence and optimal participation in the community.

TABLE 7| Cognitive Interventions for Independence and Social Integration Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Cicerone et al. (2004) USA PCT N=56	**Population:** TBI; Gender: Male=40, Female=16; *Treatment Group* (n=27); Mean Age=37.8yr; Mean Time Post Injury=33.9 mo. *Control Group* (n=29); Mean Age=37.1yr, Mean Time Post Injury=4.8 mo. **Intervention:** Participants were assigned to an Intensive Cognitive Rehabilitation Program (ICRP, treatment group) or Standard Neurorehabilitation Program (SRP, control group) for 4 mo. ICRP focused on executive and metacognitive functioning, interpersonal group processes, therapeutic work trials and placement to facilitate educational or vocational readiness. **Outcome Measures:** Community Integration Questionnaire (CIQ), Quality of Community Integration Questionnaire, Trail-Making Test Parts A (TMT-A) and B (TMT-B), California Verbal Learning Test (CVLT), Rey Complex Figure (RCF).	1. Both groups showed significant improvements on the CIQ following treatment ($p<0.001$); although the treatment group was more than twice as likely to show clinical benefit on the CIQ compared to the control group. 2. Improvements on overall neuropsychological functioning were associated with improvements on total CIQ raw scores ($p=0.03$). 3. Within the treatment group, participants who showed a clinically significant improvement on the CIQ showed a greater improvement in overall neuropsychological functioning ($p=0.045$) and attention (TMT-B; $p=0.001$).
Technology-based Interventions		
O'Neill et al. (2018) UK RCT PEDro=7 $N_{Initial}=27$, $N_{Final}=24$	**Population:** Severe ABI; TBI=16, Subarachnoid hemorrhage=3, Hypoglycemia=2; Vasculitis=2; Nutritional deficiency=1; Mean Age=45.14 yr; Gender: Male=22, Female=2; Mean Time Post Injury=5.53 yr. **Intervention:** Participants were randomly assigned to the experimental (n=10) or control group (n=14), and assessed before (baseline), during, and after intervention (return to baseline). Experimental group participants received Guide, an audio-verbal interactive micro-prompting software designed to emulate the verbal prompts and questions provided by carers or support workers. The intervention aims at improving independence by assisting individuals with personal hygiene and dressing. Control group participants received rehabilitation as usual. **Outcome Measures:** Morning Checklist (number of support worker prompts, number of safety critical and general errors, deviations from and repetitions of the necessary sequence), Satisfaction score (5-point scale).	1. Compared to baseline, there was a significantly greater reduction in the intervention group than the control group during ($p<.010$) and after ($p<.010$) the intervention for the number of prompts needed. 2. There were no significant differences between groups across the three phases in terms of number of errors, sequence errors, or satisfaction scores.
Schoenberg et al. (2008) US Case Control N=39	**Population:** TBI; *Teletherapy (TELE) Group* (n=19): Mean Age=27.4yr; Gender: Male=18, Female=1; Mean Time Post Injury=58.7mo; *Face-to-Face (FTF) Reference Group* (n=20): Mean Age=33.1yr; Gender: Male=15, Female=5; Mean Time Post Injury=29.4mo. **Intervention:** Participants in the TELE group received	1. Self-reported hours of therapy ranged from 10 to 243 hours for the TELE group and 6 to 114 hours for the FTF group. 2. There were no participants in the TELE group or the FTF group who were working

Author Year Country Study Design Sample Size	Methods	Outcome
	computer-based cognitive rehabilitation program via computers connected to the Internet at their home. The teletherapy program included individual exercises. ranging from simple attention and executive tasks to complex visuospatial memory tasks, as well as complex problem-solving and decision-making exercises. Participants in the FTF group received a minimum of six sessions of face-to-face outpatient cognitive and speech–language rehabilitation therapy. **Outcome Measures**: Independent living status, independent driving, return to work or school, total cost of the treatment and a measure of service costs per hour, hours of therapy.	or attending school, living independently, or driving at the start of the study. 3. Within-groups analysis of change from baseline to post-intervention revealed that the proportion of participants living independently, driving, and working significantly improved for both groups ($p<.01$). 4. There were no significant differences between groups in the proportion of participants living independently, driving, or returning to school or work at the conclusion of intervention ($p>.05$).
Gentry et al. (2008) Canada Pre-Post N=23	**Population:** Severe TBI; Median Age=36.5yr (IQR 18-66); Gender: Male=16, Female=7; Median Time Post-Injury=7yr (IQR 1-34). **Intervention:** Participants were each given a PDA as a cognitive aid (Palm Desktop Software) and were trained to use the PDA to facilitate performance and independence in everyday tasks (e.g., setting a calendar, entering appointments and medication schedules, and setting reminders). **Outcome Measures**: Craig Handicap Assessment and Rating Technique Revised (CHART); Canadian Occupational Performance Measure (COPM).	1. On the COPM, improvements were noted when looking at post training performance and post training satisfaction ($p<.001$). 2. Scores on the CHART-R self-assessment rating scale showed improvement as well post-training ($p<.001$). 3. Significant improvement was seen on the scores of the cognitive independence, mobility, and occupation subsections of the test ($p<.001$).
	Self-Awareness Training	
Shum et al. (2011) Australia RCT PEDro=7 N=45	**Population:** TBI; Age Range=19-57yr; Gender: Male=37, Female=8; Mean GCS= 6.25, Mean Time Post Injury=273d. **Intervention:** Participants were randomized to one of four treatment groups: self-awareness training, active control for self-awareness with training, compensatory prospective memory (PM) training, and active control for compensatory PM training. Sessions lasted 1.5hr each for 8wk. Participants were assessed at baseline and after intervention. **Outcome Measure:** Cambridge Prospective Memory Test (CAMPROMPT); number of valid diary entries; Comprehensive Assessment of Prospective Memory (CAPM); Sydney Psychosocial Reintegration Scale (SPRS).	1. All 4 groups showed no significant differences on the CAMPROMPT during the pre-intervention phase. 2. Following intervention, those with a self-awareness training component were not significantly different from those without on the change scores. 3. Scores on the CAPM and SPRS were not significantly different among the 4 groups pre- or post-intervention.
Goverover et al. (2007) USA RCT PEDro=6	**Population:** ABI; Gender: Male=16, Female=4. *Treatment Group (n=10):* Mean Age=39.5yr; Mean Time Post Injury=12.9mo; Mean GCS=4.6. *Control Group (n=10)*: Mean Age=39.2yr; Mean Time Post Injury=8.6mo; Mean GCS=3.6.	1. The treatment group showed improvement (+2.1) in task specific AAD while the control group worsened (-1.8), although the difference between groups was not significant ($p=.12$).

Author Year Country Study Design Sample Size	Methods	Outcome
N=20	**Intervention:** The experimental group received 6 sessions of self-awareness training while they performed various instrumental activities of daily living. The control group received conventional therapeutic intervention. **Outcome Measures:** Assessment of Awareness of Disability (AAD), Awareness Questionnaire (AQ), Self-Regulation Skills Inventory (SRSI), Assessment of Motor and Process Skills (AMPS), Community Integration Questionnaire (CIQ).	2. SRSI and AMPS scores improved more in the treatment group than in the control group ($p<.001$ and $p<.01$, respectively). No treatment effect was shown for AQ or CIQ.
Communication Skills Training		
Dahlberg et al. (2007) USA RCT PEDro=6 N=52	**Population:** TBI; Mean Age=41.17yr; Gender: Male=44, Female=8; Mean Time Post Injury=9.67yr. **Treatment:** Patients were randomly assigned to either the experimental (n=26) group or the control group (n=26). Individuals receiving the training focused on listening to others, communicating needs, and regulating their emotions during social interactions. There were 12 sessions, 1.5 hr each. The control group waited 3mo before undergoing treatment. Patients were assessed 5 times: baseline (wk 0), end of treatment (wk 12), at 24, 36 and 48wk. **Outcome Measure:** Profile of Functional Impairment in Communication (PFIC), Social Communication Skills Questionnaire-Adapted (SCSQ-A), Goal Attainment Scale (GAS).	1. Results of the PFIC rating scale showed significantly greater improvements on 7 of the subscales included on the PFIC: general participation ($p=.001$), quantity ($p=.024$), internal relation ($p=.009$), external relation ($p=.005$), clarity of experience ($p=.024$), social style ($p<.001$) and aesthetics ($p=.014$). 2. The SCSQ-A showed significant improvement ($p=.005$) for the treatment group compared to the control, pre- and post-intervention. 3. Over time significant improvement were noted between baseline scores and post-treatment scores for all participants receiving training on the PFIC (21 of the 30 subscales: $p<.001$). Significant improvement was noted on the SCSQ-A ($p<.001$) as well. 4. Significant improvements were made on the GAS from baseline to all post-treatment evaluations ($p<.001$).

Discussion

In a PCT study, Cicerone et al. (2004) examined the effectiveness of an intensive cognitive rehabilitation program that focused on executive and metacognitive function as well as interpersonal group processes, compared to standard neurorehabilitation. The authors found that individuals in the intensive program showed improvements in community integration, particularly for those who had improved neuropsychological functioning post intervention.

Three studies examined technology-based interventions. In an RCT, O'Neill et al. (2018) examined the effectiveness of an audio-verbal interactive micro-prompting software on independence related to activities of daily living (ADLs). The authors found that there was a significant reduction in the number of prompts needed after the intervention; however, no differences were observed in number of errors,

sequence errors or satisfaction with the software. In a case control study by Schoenberg et al. (2008), participants in the intervention group received computer-based cognitive rehabilitation, while the control group received conventional rehabilitation face-to-face. The authors found that the proportion of individuals who lived independently significantly improved in both groups; however, no differences between groups were found. In a pre-post, Gentry et al. (2008) found that the use of a personal digital assistant (Palm Desktop Software) resulted in improved independence, mobility and occupational measures.

Two RCTs addressed interventions that focused on self-awareness training. In an RCT, Shum et al. (2011) examined self-awareness training and compensatory memory training, as well as active controls for both interventions. The authors found no differences between groups on community reintegration, as measured by the Sydney Psychosocial Reintegration Scale. Similarly, in the RCT by Goverover et al. (2007), individuals who received self-awareness training did not show improvements in social integration compared to conventional therapy.

One study focused on communication skills during social interactions. In an RCT, Dahlberg et al. (2007) examined a training program that targeted communication in individuals with TBI, including listening skills, communicating needs and regulating emotions during social interactions. The authors reported that individuals in the intervention group showed significant improvements in social communication, when compared to the waitlist control.

Conclusions

There is level 1b evidence (O'Neill et al., 2018) that an audio-verbal interactive micro-prompting system may reduce the number of support-staff prompts needed for the individual to complete activities of daily living post ABI.

There is level 1b evidence (Shum et al. 2011) that compensatory memory strategies, self-awareness training, and participation in memory group sessions may not improve for community integration in individuals with TBI.

There is level 1b evidence (Dahlberg et al., 2007) communication skills training may facilitate communication in individuals with TBI when engaging in social interactions.

There is level 1b evidence (Goverover et al., 2007) that self-awareness training may not improve community integration compared to conventional therapy in individuals post ABI.

There is level 2 evidence (Cicerone et al., 2004) that intensive cognitive rehabilitation may improve community integration and neuropsychological functioning compared to standard neurorehabilitation in individuals with TBI.

There is level 3 evidence (Schoenberg et al., 2018) that computer-based cognitive rehabilitation programs and face-to-face cognitive rehabilitation programs may be equally effective in improving independence in individuals with TBI.

There is level 4 evidence (Gentry et al., 2008) that the use of a personal digital assistants may improve measures of cognitive and occupational independence, as well as mobility in individuals with TBI.

KEY POINTS

- Intensive cognitive rehabilitation may improve community integration in individuals with ABI, when compared to standard neurorehabilitation.
- The use of micro-prompting software and personal digital assistant devices may improve independence; however, computer-based cognitive rehabilitation may not be superior to standard face-to-face rehabilitation.
- Self-awareness training may not improve community integration in individuals with ABI.
- Communication skills training may improve social interactions post TBI.

Behavioural Interventions

Individuals who have sustained brain injuries, particularly of traumatic etiology, often experience changes in behaviour, including difficulties related to emotional and social behaviour that may negatively impact the individual's ability to establish interpersonal relationships (Milders, 2019). Behavioral interventions commonly target challenges related to everyday behaviours, from activities of daily living to community integration.

TABLE 8 | Behavioural Interventions for Independence and Social Integration Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Ponsford et al. (2022) Australia RCT PEDro=9 N=49	**Population:** Severe ABI; TBI=30; Stroke=13; Hypoxia=5; Tumor=1; Mean Age at Injury=43.3yr; *Intervention group (PBS+PLUS)* (n=24); Gender: Male=22, Female=2; Mean Time Post-Injury= 8.71yr; *Control* (n=25); Gender: Male=15, Female=10; Mean Time Post Injury=8.68yr. **Intervention:** Participants were randomized into a waitlist control group or a positive behavioral support intervention (PBS+PLUS) intervention over a 12mo period. Outcome measures were assessed at 12, 24 and 36mo.	1. After controlling for baseline scores, there were no significant results regarding community participation, as measured by the CIQ-R, after the intervention over the 12mo period, and after the 24mo follow-up.

Author Year Country Study Design Sample Size	Methods	Outcome
	Outcome Measures: Overt Behaviour Scale, (OBS), Challenging Behaviour Self-Efficacy Scale (CBSES), MINI International Neuropsychiatric Interview, Hospital Anxiety and Depression Scale (HADS), Community Integration Questionnaire−Revised (CIQ-R), Care and Needs Scale (CANS), Goal Attainment Scaling (GAS).	
Giles et al. (1997) USA Case Series N=4	**Population:** ABI; TBI=3, Stroke=1; Mean Age=26.75yr; Gender: Male=3, Female=1; Mean Time Post Injury=14mo. **Intervention:** Participants received a behavioural retraining program targeting washing and dressing, which involved a written component to aid learning and a behavioral observation task. **Outcome Measure:** Adaptive Behavioral Scale (ABS).	1. Marked improvements were seen on the ABS for 3 participants, and 2 participants reached maximum independence on all subscales by 3 mo. 2. As treatment progressed, all 4 participants were capable of stating the order in which activities of daily living were to be performed.
Carnevale (1996) USA Case Series N=11	**Population:** ABI; Mean Age=30.5yr; Gender: Male=7, Female=4; Mean coma duration=7.2wk. **Intervention:** Participants received a mobile Natural-Setting Behaviour Management Program (NSBM) for 1yr, that involved education, intervention, and phase-out components. **Outcome Measure:** Attainment of target behaviours.	1. By the phase-out period, there was an 82% improvement in target behaviours. 2. The greatest change (51%) occurred early in the training program during the education component. 3. An additional 27% improvement was attained during the intervention period.

Discussion

Three studies addressed behavioural interventions. In an RCT, Ponsford et al. (2022) examined the effectiveness of a positive behavioral support intervention aimed at reducing challenging behaviours in individuals with ABI. The intervention included strategies for self-regulation and increasing social support, as well as strategies to make environmental changes. The authors found no significant differences in community participation.

In a case series study, Giles et al. (1997) examined a behavioural retraining program that addressed activities of daily living in individuals with ABI, such as washing and dressing. The authors found improvements in independence at the end of the interventions and at 3 months. In a case series by Carnevale (1996), individuals with ABI and their families participated in a Natural-setting Behavior Management Program (NSBM) aimed at developing skills and learning strategies to address challenging behaviour, such as verbal of physical aggression. The authors observed improvements in target behaviours across family units, with the highest change occurring during the early education component of the program.

Conclusions

There is level 1b evidence (Ponsford et al., 2022) that a positive behavioral support intervention (PBS+PLUS) intervention may not improve community participation in individuals with ABI.

There is level 4 evidence (Giles et al., 1997) that a behavioural retraining program may improve behaviours related to activities of daily living.

There is 4 evidence (Carnevale, 1996) that a Natural-setting Behavior Management Program (NSBM) may improve challenging behaviours, such as verbal and physical aggression, in family units caring for an individual with ABI.

KEY POINTS

- Behavioral interventions may improve behaviours related to activities of daily living and behaviours within the family unit; however, they may not improve community participation.

Peer Mentorship

Mentorship has been commonly used to provide a more personalized approach to rehabilitation than group-based interventions (Hibbard et al., 2002). Peer mentors are usually individuals who have experienced similar challenges and are able to provide support to individuals that have recently sustained an injury (Dybwad & Wedege, 2022).

TABLE 9 | Mentorship for Independence and Social Integration Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Hanks et al. (2012) USA RCT PEDro=5 N=96	**Population**: TBI=96; Gender: Male=74, Female=22; Caregivers=62; *Peer Mentored Group*: Mean Age=38.46yr; Mean GCS=9.39. *TBI Control Group:* Mean Age=40.90yr; Mean GCS=9.8. *Caregiver Mentored Group:* Mean Age=51.87 yr. *Caregiver Control Group*: Mean Age=50.18 yr. **Intervention**: Participants and caregivers were randomly assigned to either a peer mentoring program or to a control group. Discussions in mentoring sessions included emotional well-being, post-TBI quality of life, and community integration. **Outcome Measures:** Community Integration Measure (CIM), Family Assessment Device (FAD), Coping	1. The TBI mentored group exhibited better behavioural control and less chaos in the living environment (FAD), good physical quality of life (SF-12), less emotion-focused coping (CISS; all p=0.04), less avoidance coping (CISS; p=0.03) and lower alcohol usage (p=0.01) compared to the control group. 2. The TBI mentored group did not show an improvement in task-oriented coping (CISS; p=0.61). 3. The TBI mentored group and control group were not significantly different in terms of community integration following treatment

Author Year Country Study Design Sample Size	Methods	Outcome
	Inventory for Stressful Situations (CISS), 12-Item Short-Form Health Survey (SF-12).	(CIM, p=0.35); however, the caregiver mentored group exhibited significantly less community integration than their non-mentored counterparts (CIM, p=0.03).
Struchen et al. (2011) USA RCT PEDro=5 N=28	**Population:** TBI; Mean Age=31.7yr; Gender: Male=24, Female=6; Mean Time Post Injury=3.5mo; Mean GCS=6.3. **Intervention**: Participants were randomly assigned to either receive a social peer mentor (treatment group) or to a waitlist (control group). **Outcome Measures**: Craig Handicap Evaluation and Reporting Technique-Short Form, Social Activity Interview, Centre for Epidemiological Studies Depression Scale (CES-D), 6-Item Interpersonal Support Evaluation List, Weekly Social Activity Survey, UCLA Loneliness Scale-Version 3, Peer Partner Satisfaction Survey, Mentor Satisfaction Survey.	1. No significant differences were found between groups on social integration, social network size, or social activity level measures following intervention. 2. Following intervention, the treatment group reported higher perceived levels of social support than the control group ($p<0.05$), who showed a decline. 3. Following intervention, CES-D scores were higher for the treatment group than for the control group ($p<0.01$). 4. 84% of participants enjoyed spending time with their mentor but only 67% felt the mentor assisted them with decreasing loneliness and increasing social activities.

Discussion

In an RCT, Hanks et al. (2012) examined the effectiveness of a peer mentoring program that focused on emotional well-being, quality of life post TBI and community integration. While there were some behavioral improvements observed in the mentored group, there were no significant differences in community integration.

Similarly, in the RCT by Struchen et al. (2011), participants reported improvements in perceived social support; however, no significant differences were found between groups in terms of social integration, social network size, or social activity level.

Conclusions

There is level 2 evidence (Hanks et al., 2012; Struchen et al., 2011) that peer mentoring may not improve community or social integration compared to no peer mentorship in individuals post TBI.

KEY POINTS

- Peer mentorship may not improve community integration in individuals with TBI.

Counseling

Individuals who have sustained an ABI often need assistance with behavioral and cognitive difficulties, as well as emotional support shortly after hospital discharge. Telephone-based counseling post discharge is a cost effective option for individuals with TBI who might benefit from problem-solving strategies and self-management skills; additionally, this counseling model has the potential to overcome geographic or financial barriers to in-person care (Hart et al., 2013).

TABLE 10| Community Rehabilitation for Independence and Social Integration Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Bell et al. (2011) USA RCT PEDro=4 $NI_{initial}$=433, NF_{inal}=299	**Population:** TBI; Mean Age=39yr; Gender: Male=323, Female=110; Mean GCS=9.7 **Intervention:** Participants were randomly assigned to either scheduled telephone intervention (treatment group; n=210) or usual care (control group; n=223) in the community. The treatment group received telephone calls over 21mo consisting of education, problem-solving, and referrals. Outcomes were assessed at 1 and 2 yr. **Outcome Measures:** Functional Independence Measure (FIM), Disability Rating Scale (DRS), Participation Assessment with Recombined Tools-Objective (PART-O), Glasgow Outcome Scale-Extended (GOS-E), 12-Item Short Form Health Survey (SF-12), Brief Symptom Inventory-18, EuroQOL (EQ-5D), Perceived Quality of Life (PQoL).	1. There were no significant differences between groups on any of the outcome measures at 1 or 2 yr.

Discussion

In an RCT, Bell et al. (2011) evaluated the use of telephone-based counseling for individuals with TBI, compared to usual care. The telephone intervention aimed to assist individuals to identify, prioritize and solve problems independently, while considering cognitive and personal limitations. Clinicians focused on help individuals engage in positive planning and goal setting related to areas of concern such as mood, work, and social activities. The authors found no significant differences for any of the outcome measures at 1 year and 2 years.

Conclusion

There is level 2 evidence (Bell et al., 2011) that telephone-based counseling may not improve independence and social integration, compared to usual care in individuals post TBI.

KEY POINTS

- Telephone-based counseling may not improve community integration in individuals with TBI.

Community Rehabilitation

Community rehabilitation involves the provision of rehabilitation services to individuals either in their homes or communities (Hopman et al., 2012). Community rehabilitation relies on the participation of diverse services, including educational, government, non-government, vocational, and other social services. Improving the efficacy of community rehabilitation has become increasingly more important given the decrease in the time individuals spend in in-patient rehabilitation (Sander, 2002).

TABLE 11| Community Rehabilitation for Independence and Social Integration Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Hopman et al. (2012) Australia PCT N=38	**Population:** TBI=39; Gender: Male=31, Female=7. *Transitional Living Unit (TLU) Group* (n=20); Mean Age=33.06yr; Mean GCS=7.06. *Community-Based Rehabilitation (CR) Group* (n=18); Mean Age=40.61yr; Mean GCS=6.6. **Intervention:** Participants were assigned to either the TLU or CR program. Outcomes were assessed at baseline, 2mo and 6mo. The TLU facilitated adjustment through experiential learning in a residential community, while CR involved participants living in their own homes. **Outcome Measures:** Community Integration Questionnaire (CIQ), Functional Autonomy Measurement Scale (FAMS), Mayo-Portland Adaptability Inventory-4 (MPAI-4).	1. The CR group had greater improvement in CIQ productivity scale scores than the TLU group (p=0.003). 2. The TLU group showed a larger improvement in their mean CIQ social integration score in comparison with the CR group (p=0.007). 3. Both groups revealed significant improvements in instrumental activities of daily living (FAMS, p=0.002) and an increase in social participation (MPAI-4, p<0.05) from baseline to 6mo.
McLean et al. (2012) Canada Case Control N=42	**Population:** TBI; *Treatment Group* (n=23); Mean Age=48.61yr; Gender: Male=15, Female=8; Mean Time Post Injury=20.02 yr. *Control Group* (n=19); Mean Age=41.58yr; Gender: Male=13, Female=6; Mean Time Post Injury=12.63 yr. **Intervention:** Participants attending a brain injury drop-in centre (BIDC) were compared to those who did not attend (control group). The BIDC was located in a community setting and it focused on participation in social and leisure activities. **Outcome Measures:** Adult Subjective Assessment of Participation (ASAP), Community Integration Questionnaire – Social Integration scale (CIQ-SI).	1. Of the participants in the treatment group, 47.8% wished to attend the BIDC more often and reported that 36.9% of all their social/leisure activities occurred at the BIDC. 2. The treatment group reported significantly higher levels and frequency of social participation on the CIQ-SI (p=0.011 and p=0.034 respectively), as well as increased activities outside of the home (p=0.002), activities with others (p=0.014) and

Author Year Country Study Design Sample Size	Methods	Outcome
		satisfaction with performance (p=0.042) on the ASAP than the control group.
Wheeler et al. (2007) USA PCT N=36	**Population:** TBI; *Treatment Group* (n=18); Mean Age=33.67yr; Gender: Male=12, Female=6; Mean Time Post-Injury=67.22mo. *Control Group* (n=18); Mean Age=34.83yr; Gender: Male=12, Female=6; Mean Time Post-Injury=48.33mo; Length of coma= >1hr. **Intervention:** Participants attended an intensive community-based life skills training program 6hr/d for 6wk. The intervention involved one-on-one intensive training that addressed concerns such as self-care, money management, home management, and social behaviour. Matched community dwelling individuals served as the control group. **Outcome Measures:** Community Integration Questionnaire (CIQ), Satisfaction with Life Questionnaire (SLQ).	1. The treatment group showed significant improvement on the CIQ home integration subscale (p=0.01) and the productivity subscale (p=0.02); no significant changes were seen in the control group. 2. The treatment group showed a decrease on the SLQ, whereas the control group showed an increase; neither change was significant.

Discussion

Three studies addressed community rehabilitation interventions. In a PCT study, Hopman et al. (2012) examined two different living accommodations for individuals with ABI. Individuals were assigned to either a transitional living unit (TLU) or to receive community-based rehabilitation (CR) while living at home. The authors found that, while both groups showed improvements in instrumental activities o daily living and in social participation after the intervention, individuals who lived in the TLU showed larger improvements in social integration. In addition, individuals in the community-based rehabilitation group showed improved independence when performing activities than those who lived in the TLU.

In a case control study, McLean et al. (2012) compared a group of individuals who had attended a brain injury drop in centre (BIDC) in the community to a group of individuals who did not attend. The authors found that those who attended the program reported that most of their leisure and social activities occurred at the centre; in addition, individuals in this group reported higher levels and frequency of social participation, as well as social activities outside the home.

In a PCT study, Wheeler et al. (2007) found that individuals who participated in a community-based life skills training program showed significant improvements in productivity and community integration, compared to a control group of community-dwelling individuals. The intervention involved intensive one-on-one training addressing everyday life activities such as self-care, money management, home management and social behaviour in individuals who sustained a TBI.

Conclusions

There is level 2 evidence (Hopman et al., 2012) that living in a transitional living unit may improve social integration compared to community-based rehabilitation in individuals post ABI; however, both living settings may improve performance of instrumental activities of daily living and social participation.

There is level 2 evidence (Wheeler et al., 2007) that intensive community-based life skills training may improve community integration in post TBI.

There is level 3 evidence (McLean et al., 2012) that attending a brain injury drop-in centre in the community may improve social participation in individuals with TBI.

KEY POINTS

- Living in a transitional living unit may improve social integration in individuals post ABI, while community-based rehabilitation while living at home may facilitate performance in activities of daily living.
- Community-based life skills intensive training and brain injury drop-in centres in the community that address leisure and social activities may improve community integration and participation in individuals with TBI.

Multimodal Interventions

Therapies may be evaluated in combination or comparatively to determine treatment effects. Multimodal interventions are usually delivered a multidisciplinary team and target multiple deficits in individuals with ABI by combining multiple therapeutic interventions. Multidisciplinary teams often involve the collaboration of professionals such as physiotherapists, occupational therapists, psychologists, social workers, speech and language therapists, as well as rehabilitation physicians. The implementation of multimodal interventions is particularly beneficial for social reintegration post ABI since there is often a compounding effect arising from multiple impairments stemming from the injury which may prevent an individual from successfully reintegrating into the community (Powell et al., 2002).

TABLE 12| Multimodal Interventions for Independence and Social Integration Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Powell et al. (2002) USA RCT PEDro=4 $N_{initial}$=110, N_{final}=94	**Population:** Severe TBI; Gender: Male=71, Female=23. *Outreach Group (n=48):* Mean Age=34yr; Mean Time Post Injury=4 yr. *Information Group (n=46):* Mean Age=35yr; Mean Time Post Injury=2.7 yr. **Intervention:** Participants were randomly allocated to either an outreach treatment group provided by a multidisciplinary team (2-6hr/wk, 6-12wk) or an information treatment group which involved a therapist providing a booklet of resources at a single home visit. **Outcome Measures:** Barthel Index (BI), Brain Injury Community Rehabilitation Outcome-39 scale (BICRO-39), Functional Assessment Measure (FAM), Functional Independence Measure (FIM), Hospital Anxiety and Depression Scale (HADS).	1. The outreach group had greater change scores on the self-organization ($p<0.025$) and psychological wellbeing ($p<0.05$) subscales of the BICRO-39 than the information group. 2. The outreach group showed significantly greater change scores on the BI ($p<0.05$) and BICRO-39 ($p<0.05$) in comparison with the information group.
Borg et al., (2020) Australia Cohort N=187	**Population:** ABI; *Transitional Rehabilitation Services (TRS)* (n=63): TBI= 48.4%, CVA=19.4%, Subdural Hematoma=4.8%, Hypoxia=11.3%, Other=16.1%; Median Age at Injury=38yr (IQR 26-47); Gender: Male=48, Female=15; Median GCS=8 (IQR 4-12); Time Post Injury=Not Reported; *Historical Group (HIST)* (n=124); TBI= 71.8%, CVA= 7.3%, Subarachnoid Hemorrhage=11.3%, Subdural Hematoma=3.2%; Hypoxia=3.2%, Other=6.5%; Median Age=47yr (IQR 23-59); Gender: Male=89, Female=98; Median GCS=8 (IQR 4-13); Time Post Injury=Not Reported. **Intervention:** Participants who received an ABI transitional rehabilitation service (ABI TRS) for 2-4x/wk for 10wk intervention were compared to a historical group. Interdisciplinary care included medical (rehabilitation physician), clinical and neuropsychology, occupational therapy, speech pathology, physiotherapy, social work, and exercise physiology. The total program intervention was 12wk. **Outcome Measures:** Depression Anxiety and Stress Scale (DASS-21), Mayo-Portland Adaptability Inventory (MPAI-4), 5 Point Sydney Psychosocial Reintegration Scale (SPRS-2), Care and Needs Scale (CANS), EuroQOL Visual Analog Scale (EQ-VAS).	1. Participation scores on the MPAI-4 were statistically higher at discharge for people in the ABI TRS group as compared to HIST (MD [95% CI] = 4 [1, 7]; d = 2.75). The change in participation scores from discharge to 3mo was statistically different between groups (MD = −5 [−9, −1]; d = −2.81); with a more favorable change for participants with ABI TRS compared to HIST. 2. Occupational activity scores of the SPRS were statistically lower for people in the ABI TRS compared to HIST at discharge (MD [95% CI] = −0.5 [−0.5, −0.4]) and 3mo (MD = −0.3 [−0.4, −0.2]). The change in scores from discharge to 3mo was statistically different between groups (MD = 0.20 [0.13, 0.26]; d = 6.07). 3. Living skills scores of the SPRS were statistically lower for people in the ABI TRS group compared to HIST at both discharge (MD [95% CI] = −0.24 [−0.30, −0.18]) and 3mo (MD = −0.07 [−0.12 − 0.03]. The change in scores from discharge to 3mo was different between groups (MD = 0.16 [0.11, 0.22]; d = 5.33), with participants with ABI TRS showing a greater improvement.
Perumparaichallai et al. (2020) USA Pre-Post N=107	**Population**: TBI=62, CVA=27, Anoxia, Tumor or infection=14; Mean Age=35.81yr; Gender: Male=62, Female=45; Mean Time Post Injury=3.02yr; Severity: Mild=3, Moderate-to-Severe=36, Severe=18, Unknown=3. **Intervention:** Participants attended holistic milieu-oriented neurorehabilitation between 1996 and 2016. Participants completed one or more of the intervention programs that aimed to facilitate home	1. When categorized based on their MPAI-4 Total score, most participants reported good functioning independence (no limitations=25%, mild limitations=20%, mild to moderate limitations=42%). 2. Psychosocial data from the LOQ revealed positive findings regarding patients' marital status (Married/ relationship=47.7%), living situation (living independently with or without others=97.2%), and quality of social

Author Year Country Study Design Sample Size	Methods	Outcome
	and community independence, social relationships and quality of life, work and/or school re-entry. The intervention duration was 3-5d/wk, 4-6h/d. Primary outcome measures were assessed at program admission, discharge, and follow-up in 2016. Secondary outcome measures were assessed at follow-up in 2016. **Outcome Measures**: Productivity status (e.g., return-to-work/school), driving status, Mayo-Portland Adaptability Inventory-4 (MPAI-4) and a long-term outcome questionnaire (LOQ) specifically developed for this study.	life (has a friend to confide=75.7%, participation in social activities at least once/wk=57%, no challenges engaging in social activities=69.2%).
Geurtsen, et al. (2012) Netherlands Post-Test $N_{Initial}$=67, N_{Final}=63 *Follow-up study of Geurtsen et al. (2011)	**Population:** TBI=42, Stroke=6, Tumor=9, Encephalitis=4, Hypoxia=2; Mean Age= 24.7±7.2yr, Gender: Male=42, Female=21; Mean Time Post Injury=5.1±5.3yr; Mean GCS=7.8 **Intervention:** Participants attended a structured residential treatment program consisting of three modules: the independent living module (100h per person), the social-emotional module (110h per person), and the vocational module (44h per person). Outcome measures were assessed 1 and 3yr post treatment. **Outcome Measures:** Community Integration Questionnaire (CIQ), Employability Rating Scale (ERS), living situation, school, work situation, work hours, Center for Epidemiological Studies Depression Scale (CES-D), World Health Organization Quality of Life Scale Abbreviated (WHOQOL-BREF; 5 scales)	1. There were no significant differences for any of the outcome measures between the 1yr and 3yr follow-up assessment (p>.05), indicating that the pos-intervention gains at 1yr were maintained at 3yr follow-up.
Geurtsen, et al. (2011) Netherlands Pre-Post $N_{Initial}$=70, N_{Final}=67	**Population:** TBI=47, Stroke=7, Tumor=10, Encephalitis=4, Hypoxia=2; Mean Age: 25.1±7.9yr; Gender: Male=46, Female=24; Mean Time Post Injury=5.2y; Mean GCS=7.5. **Intervention:** Participants attended a structured residential treatment program consisting of three modules: the independent living module (100h), the social-emotional module (110h), and the vocational module (44h). Outcome measures were assessed at inclusion (T0), the start of the treatment 3mo later (T1), the end of the treatment (T2) and 1yr follow-up after the end of treatment (T3) **Outcome Measures**: Community Integration Questionnaire (CIQ), Employability Rating Scale (ERS), living situation, school, work situation, work hours, Center for Epidemiological Studies Depression Scale (CES-D), EuroQOL quality of life scale (EQ-5D), World Health Organization Quality of Life Scale Abbreviated (WHOQOL-BREF; 5 scales), Global Assessment of Functioning (GAF) scale.	1. Participants' societal participation improved significantly immediately after treatment (CIQ; p<.001). 2. Living independently rose from 25.4% before treatment to 72.4% after treatment and was still 65.7% at follow up.

Author Year Country Study Design Sample Size	Methods	Outcome
Lippert-Gruner et al. (2002) Germany Post-Test N=48	**Population:** Severe TBI; Mean Age=31.8yr; Gender: Male=36, Female=12; GCS Score= <8; Time Post-Injury=>24h. **Intervention:** Participants were interviewed 1yr post discharge from an early-onset continuous rehabilitation treatment program. The program comprised physical therapy, occupational therapy, speech therapy and behavioural therapy. **Outcome Measures:** Coma Remission Scale, Barthel Index, Functional Independence Measure, Disability Rating Scale.	1. At 1yr, 35.4% were at work and 83.3% were completely independent of care. 2. Most patients were independent with ADLs but still had marked behavioural and speech deficits, which caused difficulty with reintegration into school/professional life. 3. Behavioural deficits ($p<0.01$) and speech disturbances ($p<0.05$) were more common in those with occupational challenges.
Malec (2001) USA Pre-Post $N_{Initial}$=113, N_{Final}=96	**Population:** *Program Graduates* (n=96); TBI=72%, CVA=19%, Other=9%; Mean Age=34.2±12.2yr; Gender: Male=73%, Female=27%; Mean Time Post Injury=4.6±6.6yr; Severity: Severe=82%, Undetermined=4%; *Dropouts* (n=17); TBI=71%, CVA=6%, Other=23%; Mean Age=29.4±12.4yr; Gender: Male=71%, Female=29%; Mean Time Post Injury=1.3±1.5yr; Severity: Severe=92% **Intervention:** Participants attended a comprehensive day treatment (CTD) program involving daily group sessions and individual therapy as needed, for an average of 189.5d. The CTD program utilized a transdisciplinary approach, supportive feedback, and a variety of therapeutic modalities (peer, staff, videotape). The program sessions aimed to improve: Self-awareness, coping and compensation skills, personal organization, social skills, emotional and behavioral self-management participation in social, work, and leisure activities, and health maintenance. Outcome measures were assessed before and after the program, and at 1yr follow-up. **Outcome Measures**: Independent living status, vocational independence scale, Mayo-Portland Adaptability Inventory (MPAI-22), Goal Attainment Scaling (GAS)	1. Of the 552 goals set for graduates of the program and scaled using GAS, 81% were met at an expected level of outcome or better. 2. A significant improvement on the overall level of disability was observed at program completion (MPAI-22; $p<.001$). 3. At 1yr follow-up, 72% of graduates were living independently, 39% were working independently, 10% were in transitional placements, and 18% were in supported or volunteer work.

Discussion

In an RCT, Powell et al. (2002) examined the effectiveness of a rehabilitation intervention delivered by a multidisciplinary team, including two occupational therapists, a physiotherapist, a clinical psychologist, a physiotherapist and a social worker. The multidisciplinary team assisted individuals to achieve long-term treatment goals such as independence, self-care activities and return to work. Individuals in the control condition received an information booklet. The authors found that individuals in the intervention group showed significant gains in activities of daily living performance and independence in personal

care, as measured by the Barthel Index (BI) and the Brain Injury Community Rehabilitation Outcome-39 scale (BICRO-39).

In a cohort study, Borg et al. (2020) retrospectively examined the effectiveness of an acquired brain injury transitional rehabilitation service, compared to a historical comparison group. Individuals in the intervention group received interdisciplinary care that included rehabilitation services, clinical psychology and neuropsychology, occupational therapy, speech pathology, physiotherapy, social work, and exercise physiology. The authors found significant differences between groups in social participation and living skills from discharge to 3 months, favoring the intervention group.

In a pre-post study by Perumparaichallai et al. (2020), examined a milieu-oriented neurorehabilitation intervention delivered by a multidisciplinary team. The intervention aimed to facilitate iondependence at home and in the community, social relationships and quality of life, as well as work and school re-entry among individuals with ABI. Up to 30 years post injury, 89% of participants were productive, with 73% in school and/or work, excluding individuals who retired.

Improved independence and social participation were also reported among participants with ABI who took part in the Brain Integration Program, a community reintegration program that addressed three modules, independent living, socioemotional, and vocational rehabilitation (Geurtsen et al., 2011). The program involved a multidisciplinary team consisting of professionals such as social workers, occupational therapists, and speech-language therapists. In addition, in a follow-up study (Geurtsen et al., 2012), improvements were maintained at one and three years post discharge, suggesting long-term benefits for individuals with ABI.

Similarly, in a pre-post study by Malec (2001), participants showed significant improvements in functional independence and levels of participation following a multidisciplinary intervention aimed at building cognitive and behavioural skills through a variety of therapeutic modalities, such as self-awareness, social skills, emotional and behaviour management.

In a post-test study, Lippert-Gruner et al. (2002) examined a complex early rehabilitation intervention that included multimodal sensory stimulation, facio-oral training, occupational therapy, speech therapy and cognitive-behavioral therapy. The authors found that the majority of patients achieved a high level of independence 1 year after TBI; however, given the presence of behavioural and speech difficulties, less than 50% of individuals were able to return to work.

Conclusions

There is level 2 evidence (Powell et al., 2002) that rehabilitation program delivered by a multidisciplinary team may improve performance on activities of daily living and community functioning compared to an information booklet in individuals post severe TBI.

There is level 2 evidence (Borg et al., 2020) that an interdisciplinary rehabilitation intervention may improve participation and living skills in individuals with ABI.

There is level 4 evidence (Perumparaichallai et al., 2020) that a holistic milieu-oriented neurorehabilitation program delivered by a multidisciplinary team may improve community integration in individuals with ABI.

There is level 4 evidence (Geurtsen et al., 2011; Geurtsen et al., 2012) that a community reintegration program delivered by a multidisciplinary team may improve independence and social participation post ABI.

There is level 4 evidence (Malec, 2001) that a comprehensive multidisciplinary day program incorporating daily group sessions and a transdisciplinary approach may improve independence and participation in individuals with ABI.

There is level 4 evidence (Lippert-Gruner et al., 2002) that early-onset multimodal rehabilitation therapy may improve independence in individuals with severe TBI.

KEY POINTS

- Rehabilitation programs delivered by multidisciplinary teams may improve performance in activities of daily living, independence, and community integration in individuals with ABI.

Life Satisfaction and Quality of Life

Life satisfaction is an important indicator of the efficacy of a rehabilitative intervention for individuals with brain injuries. Compared to healthy individuals, those with an ABI have reported less satisfaction in multiple aspects of life, such as social relationships, vocation, leisure, as well as physical and psychological health (Atay et al., 2016; Jacobsson & Lexell, 2013).

Quality of life (QoL) is a subjective measure that takes many factors into account, including but not restricted to health and social functioning, psychological health and material well-being (Mailhan et al., 2005). Factors such as cognitive functioning, physical functioning, sexual functioning, vocational outcomes, and individuals perception have also been associated with QoL outcomes (Esbjörnsson et al., 2013; Forslund et al., 2013; Jacobsson & Lexell, 2013; Sander et al., 2013). As perception influences

health related QoL, some individuals may have greater awareness of their obstacles and less denial of their limitations based on their level of impairment. This awareness may influence anxiety, depression, and life satisfaction. Satisfaction with QoL is a complex concept, and its definition and validity can vary due to its subjectivity.

TABLE 13 | Interventions for Life Satisfaction and Quality of Life Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Rehabilitation Nursing Models		
Yang et al. (2022) China RCT PEDro=4 N=60	**Population:** TBI; *Intervention group* (n=30); Mean Age=50.96yr; Gender: Male=16, Female=14; GCS <9; Time Post Injury=not reported; *Control group* (n=30); Mean Age=50.91yr; Gender: Male=15, Female=15; GCS <9; Time Post Injury=Not Reported. **Intervention:** The intervention group received a nursing rehabilitation model based on Orem's self-care theory, while the control group received early rehabilitation nursing. **Outcome Measures:** Nursing satisfaction, Fugl-Meyer Motor Function Scale (FMA), NIH-SS scoring, Barthel index (BI), Quality of Life Scale (QOLS).	1. Quality of Life scores before the nursing rehabilitation model exhibited no significant differences between groups ($p > 0.05$). After the nursing intervention, Quality of life scores decreased in both groups, showing an improvement in quality of life. 2. The scores of physiological function, psychological function, social function, and health self-cognition in the intervention group were lower than those in the control group, and the difference was statistically significant ($p< 0.05$).
Resilience Interventions		
Assonov (2021) Ukraine RCT PEDro=6 N=70	**Population:** TBI; *Two-step Resilience-Oriented Intervention (TROI) Group* (n=35); Mean Age= 47.22yr; Gender: Female=1, Male=34; Time Post Injury= Median 6yr (IQR 5-6); *Treatment As Usual (TAU) Group* (n=35); Mean Age= 45.65yr; Gender: Female=1, Male=34; Injury Severity: Mild TBI=7, Moderate TBI=28; Time Post Injury=Median 6yr (IQR=5-7). **Intervention:** Participants received the two step resilience intervention with two steps: the first step (sessions 1-3) addressing cognitive factors of resilience, such as adaptive executive skills, memorization skills, ability to focus attention, and the second step addressing emotional factors, such as positive outlook and the ability to nourish positive emotions as well as manage the negative ones over six 1hr sessions. The treatment group received usual therapy. **Outcome Measures:** Connor-Davidson Resilience Scale (CD-RISC), Hospital Anxiety and Depression Scale (HADS), Montreal Cognitive Assessment Scale (MoCA), Neurobehavioral Symptom Inventory (NSI), Posttraumatic Stress Disorder Checklist 5 (PCL-5), Chaban Quality of Life Scale (CQLS), Positive and Negative Affect Scale (PANAS)	1. Within group analysis showed significant improvement (CD-RISC p=<0.001; MoCA p=<0.001; NSI<0.001; HADS-D p=<0.001; PCL-5 p=<0.001; PANAS+ p=<0.001; CQLS p=<0.001) in all outcomes after intervention. 2. The between group comparison showed that TROI group demonstrated a significantly higher increase in resilience (p<0.001), cognitive performance (p<0.001), positive affect (p<0.001), and, to a lesser extent, in quality of life (p=0.017), as well as significantly higher decrease in posttraumatic symptoms (p<0.001), and, to a lesser extent, in neurobehavioral symptoms (p=0.030).
Art Therapy		
Di Vita et al. (2022) Italy	**Population:** Severe TBI; *PsyArt Group* (n=4); Mean Age=38.5yr; Gender: Not reported; Time post-injury=Not Reported; *ArtPsy Group* (n=5); Mean	1. QOLIBRI did not show significant differences between ArtPsy and PsyArt groups, except for a significant difference

Author Year Country Study Design Sample Size	Methods	Outcome
PCT $N_{initial}$=12 N_{final}=9	age=30.6yr; Gender: Not Reported; Time Post-Injury=Not Reported. **Intervention:** Participants received Psychotherapy and Art therapy using activities and techniques based on theoretical and methodological principles of transactional analysis, with special emphasis on relational experience and the script identity. The intervention aimed at improving social function, quality of life and emotional autoregulation. **Outcome Measures:** The Patient Competency Scale (PCRS), Mayo-Portland adaptability index (MPAI-4), Quality of Life after Brain Injury (QOLIBRI), Clinical Outcomes in Routine Evaluation (CORE-OM), Brain Injury Brief Inventory (BIGI), Difficulties in Emotional Regulation scale (DERS), Brief-COPE, Beck Depression Inventory (BDI-II) and State-Anxiety Inventory for Adults (STAI-X).	at baseline in the 'physical problems' subscale between groups (p <.05).
Residential Community Programs		
Geurtsen et al. (2012) Netherlands Post-Test $N_{Initial}$=67, N_{Final}=63 *Follow-up study of Geurtsen et al. (2011)	**Population:** TBI=42, Stroke=6, Tumor=9, Encephalitis=4, Hypoxia=2, Mean Age= 24.7±7.2yr, Gender: Male=42, Female=21, Mean Time Post Injury=5.1±5.3yr, Severity: Mean GCS=7.8 **Intervention:** Participants attended a structured residential treatment program consisting of three modules: the independent living module (100h), the social-emotional module (110h), and the vocational module (44h). Outcome measures were assessed 1 and 3yr. **Outcome Measures:** Community Integration Questionnaire (CIQ), Employability Rating Scale (ERS), living situation, school, work situation, work hours, Center for Epidemiological Studies Depression Scale (CES-D), World Health Organization Quality of Life Scale Abbreviated (WHOQOL-BREF; 5 scales)	1. There were no significant differences for any of the outcome measures between the 1yr and 3yr follow-up assessment (p>.05), indicating that the post-intervention gains at 1yr were maintained at 3yr follow-up.
Geurtsen, et al. (2011) Netherlands Pre-Post NI_{nitial}=70, N_{Final}=67	**Population:** TBI=47, Stroke=7, Brain tumor=10, Encephalitis=4, Hypoxia=2; Mean Age: 25.1±7.9yr; Gender: Male=46, Female=24; Mean Time Post Injury=5.2y; Severity: Mean GCS=7.5 **Intervention:** Participants attended a structured residential treatment program consisting of three modules: the independent living module (100h), the social-emotional module (110h), and the vocational module (44h). Outcome measures were assessed at inclusion (T0), at 3mo (T1), at the end of the treatment (T2) and 1yr follow-up (T3). **Outcome Measures**: Community Integration Questionnaire (CIQ), Employability Rating Scale (ERS), living situation, school, work situation, work hours, Center for Epidemiological Studies Depression Scale	1. Participants' levels of depression decreased significantly immediately after treatment (CES-D; p<.001). 2. Participants' quality of life improved significantly immediately after treatment (EQ-5D; p=.008; EuroQOL Health Status visual analog scale; p<.001; GAF p<.001; WHOQOL-BREF; overall; p=.008).

Author Year Country Study Design Sample Size	Methods	Outcome
	(CES-D), EuroQOL quality of life scale (EQ-5D), World Health Organization Quality of Life Scale Abbreviated (WHOQOL-BREF; 5 scales), Global Assessment of Functioning (GAF) scale.	
In-patient Rehabilitation		
Cusick et al. (2003) USA Case Control N=132	**Population:** TBI; Gender: Male=84, Female=48; Time Post Injury=1-3yr; Severity: Moderate=14, Severe=119. **Intervention:** Patients received post-injury care through the Colorado Medicaid Program (CMP; n=66) and were compared to a matched sample who did not receive this service (control group, n=66). Patients were interviewed after treatment. **Outcome Measures:** Craig Handicap Evaluation and Reporting Technique-Short Form (CHART-SF), Sickness Impact Profile-Alertness Behaviour, Satisfaction with Life Scale (SWLS), Short-Form Health Survey – Short Form (SF-12).	1. The CMP group showed significantly fewer problems in terms of SF-12 mental health (p=0.006), alcohol use (p=0.003), and risk of using alcohol (p<0.001) compared to controls. 2. The CMP group used significantly more case management (p=0.005), physical therapy (p=0.038), second rehabilitation admission (p=0.013), and group home stay (p=0.008) compared with the controls. 3. The CMP group had poorer outcomes on the total CHART-SF (p<0.01) and on the physical independence, cognitive independence, mobility, and occupational subscales. 4. No significant differences were found on SWLS (p=0.771).

Discussion

In an RCT, Yang et al. (2022) compared a nursing rehabilitation model based on Orem's self-care theory to conventional rehabilitation nursing. The authors found that quality of life improved in both the intervention and the control group; however, the intervention group showed statistically significant improvements in social function, psychological function and health self-cognition, compared to the control group.

In an RCT, Assonov (2021) examined a resilience intervention that addressed both cognitive and emotional factors among individuals who sustained a TBI, compared to usual care. The authors found that the individuals in the resilience group showed higher levels of quality of life. Two studies, a pre-post and a post-test, addressed a residential community program that involved independent living, social-emotional, and vocational components (Geurtsen, et al., 2011; Geurtsen et al., 2012). The authors found that individuals who attended the program showed improvements in quality of life post ABI, that were maintained at three-year post-discharge.

In a PCT study, Vita et al. (2022) examined the use of art therapy to improve social function, quality of life and emotional regulation in individuals with severe TBI. The authors found no significant differences between groups in quality of life, as measured by the Quality of Life after Brain Injury (QOLIBRI) scale. Similarly, no but there were no significant improvements on satisfaction with life were reported by

Cusick et al. (2003) in a case control study that compared individuals who received Medicaid home and community-based services to those who did not.

Conclusions

There is level 1b evidence (Assonov, 2021) that a resilience intervention may improve quality of life post TBI, compared to usual care.

There is level 2 evidence (Yang et al., 2022) that a nursing rehabilitation model based on Orem's self-care theory may improve quality of life in individuals with TBI.

There is level 3 evidence (Cusick et al., 2003) that the Colorado Medicaid Program may not improve life satisfaction in individuals with TBI.

There is level 4 evidence (Geurtsen et al., 2011; Geurtsen et al., 2012) that a structured residential treatment program may improve quality of life in individuals with ABI.

KEY POINTS

- Orem's nursing rehabilitation, a resilience intervention, and a structured residential program may improve quality of life post TBI.
- A Medicaid program may not improve quality of life post TBI, when compared to no service.

Social Support Groups

While social isolation can occur across all ages and at all stages of life, individuals who have sustained a TBI often experience motor, socio-emotional and cognitive impairments that may result in limited social participation and increased loneliness (Salas et al., 2022). It can be difficult for individuals with TBI to return to their former levels of occupational and leisure activities, leading to limited reintegration to their communities, as well as low life satisfaction, perceived quality of life and social support (Stålnacke, 2007). In those with more severe injuries, impairments related to social cognition, such as difficulties with affective empathy and facial emotion recognition may also affect social functioning (McDonald, 2013)

TABLE 14 | Social Support Groups for Life Satisfaction and Quality of Life Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Vandiver & Christofero-Snider (2000) USA Case Series N=49	**Population:** TBI; Gender: Male=34, Female=15. **Intervention:** Patients attended a community psychosocial support program (2x per mo). **Outcome Measures:** Self-Efficacy Scale, Quality of Life interview.	1. At follow-up, self-efficacy scores increased from 3.36 to 3.61 ($p<0.05$). 2. Participants perceived social relations, leisure and finances as important variables contributing to quality of life.

Discussion

Vandiver and Christofero-Snider (2000) found similar results in individuals with TBI who actively participated in a brain injury club; participants' self-efficacy and sense of personal competency improved as a result of planning, organizing, and implementing club events. The authors also found a significant reduction in feelings of hopelessness post intervention, as measured by the Beck Hopelessness Scale (BHS), and Purpose in Life Test (PIL), and the Perceived Self-Regulatory Ability Inventory (PSRA); in addition, and a positive attitude among participants that was maintained at 1 year follow-up, with individuals returning to work or education (Vandiver & Christofero-Snider, 2000).

Conclusions

There is level 4 evidence (Vandiver & Christofero-Snider, 2000) that social support groups may increase self-efficacy and quality of life as well as decrease feelings of hopelessness in individuals post TBI.

KEY POINTS

- Social supports groups may decrease feelings of hopelessness and increase quality of life among those with moderate to severe TBI.

Leisure Education Programs

Patient education is critical for individuals to learn strategies for the management of their symptoms, problem-solving and goal setting, while families benefit from learning related to how to help their loved ones recover and obtain important information about the injury and its consequences (Hart et al., 2018). Some educational interventions can assist individuals to engage in leisure activities, help them be social and enjoy recreation.

TABLE 15 | Leisure Education for Life Satisfaction and Quality of Life Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Carbonneau et al. (2011) Canada Pre-Post N=5	**Population:** TBI; Mean age= 39.33yr; Gender: Male=3; Time Post Injury= >1yr. **Intervention:** Participants took part in a Leisure Education Program (LEP) which involved ten one-on-one sessions held over 7-10wks. The program focused on fostering awareness/participation in new and/or alternative ways to pursue leisure activities, building skills in individually selected leisure pursuits, and fostering increased leisure satisfaction. Outcome measures were assessed at baseline, at the end of the program and 1mo follow-up. **Outcome Measures:** Katz Adjustment Scale (KAS), Leisure Satisfaction Scale (LSS), Leisure self-efficacy scale, General Well-Being Schedule, Sickness Impact Profile (SIP), Mayo Portland Adaptability Inventory (MPAI-4), the facilitator (RA) log in which the RAs documented their experiences with the program, audio-recorded program sessions, interviews with participants	1. All three participants with TBI reported improved leisure satisfaction and self-efficacy following the completion of the LEP. 2. This extended to improvements in general wellbeing and health-related quality of life for two of the three participants.
Mitchell et al. (2014) Australia Pre-Post $N_{Initial}$=13, N_{Final}=12	**Population:** TBI=10, Non-Traumatic ABI=2; Mean Age=36yr; Gender: Male=8, Female=4; Time Post Injury: <12mo=1, 12-24mo=4, 24-48mo=7. **Intervention:** Participants took part in Pushing the Boundaries, a 1wk residential leisure education program (LEP) conducted in group format. The LEP provided participants with the opportunity to engage in various sporting and recreational activities and involved sessions on social communication skills. Outcome measures, except the semi-structured interview, were assessed prior to, immediately following and at 3mo post program. **Outcome Measures**: Leisure Satisfaction Scale (LSS), World Health Organisation Quality of Life – BREF (WHOQOL-BREF) and Rosenberg Self Esteem Scale (RSES).	1. Participants showed significant improvements in leisure satisfaction 3mo post program (LSS; p=0.002) 2. Participants showed significant improvements in self-esteem at 3mo post program (RSES; p=0.03) 3. Participants showed significant improvements in QoL (p=0.02 to 0.008 for four domains of the WHOQOL-BREF) at 3mo post program.

Discussion

Carbonneau et al. (2011) examined the effectiveness of a leisure education program that focused on self-awareness, leisure awareness and resources required to enhanced participation in leisure activities. Participants in this study reported some benefit in leisure satisfaction and self-efficacy, which in turn, helped improve general well-being and quality of life (Carbonneau et al., 2011). Similarly, Mitchell et al. (2014), found that a leisure education program that provided participants with the opportunity to

engage in various sporting and recreational activities resulted in significant improvements in leisure satisfaction, self-esteem and quality of life (Mitchell et al., 2014).

Conclusions

There is level 4 evidence (Carbonneau et al., 2011; Mitchell et al., 2014) that leisure education programs may improve leisure satisfaction, self-esteem, well-being and quality of life in individuals with moderate to severe ABI.

KEY POINTS

- Leisure education programs may improve quality of life post ABI, as well as leisure satisfaction, self-esteem, and general well-being.

Physical Activity

Physical activity across all ages has been associated with increase quality of life, particularly in relation to leisure activities (Pucci et al., 2012). Individuals with moderate to severe TBI may be predominantly inactive, leading to increased risks of chronic disease in this population (Johnson et al., 2023). Physical activity post TBI may have several benefits, such as improved cognition, decreased stress, and social benefits such as social interactions with peers, building new friendships and enhancing communication skills (Pinto et al., 2021).

TABLE 16 | Physical Activity for Life Satisfaction and Quality of Life Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Williams et al. (2022) Australia RCT PEDro=8 N=114	**Population:** TBI; *Experimental group* (n=70); Mean Age=34yr; Gender: Male=54, Female=16; Mean GCS=6; Time Post Injury=114d. *Control group* (n=74); Mean Age=34; Gender: Male=58, Female=16; Mean GCS=6; Time Post Injury=116d. **Intervention:** Participants in the experimental group received 3 60-min sessions of non-ballistic exercise rehabilitation per wk, replaced by ballistic resistance training. The control group received non-ballistic exercise rehabilitation of equivalent time. The non-ballistic exercise rehabilitation included balance exercises, lower limb stretching, strengthening	1. For health-related quality of life, the groups had similar results. At 3mo, the experimental group scored 0.03 points (95% CI –0.01 to 0.06) lower on the AQOL-6D than the control group. At 6mo, the experimental scored 0.01 points (95% CI –0.04 to 0.04) lower than the control group. 2. The intervention resulted in no significant differences between groups in health-related quality of life.

Author Year Country Study Design Sample Size	Methods	Outcome
	exercises, cardiovascular fitness training and gait training. **Outcome Measures:** Mobility Assessment tool (HiMAT), 10m Walk, Muscle strength, Single leg stance, Assessment of Quality of Life (AQOL-6D).	
	Dance	
Sarkamo et al. (2021) Finland RCT Crossover PEDro=7 N=11	**Population:** TBI; *AB Group* (n=6): Mean Age=36.3yr; Gender: Male=3, Female=3; Mean Time Post Injury=9.2yr; *BA Group* (n=5): Mean Age=33.7yr; Gender: Male=4, Female=1; Mean Time Post Injury=5.8yr. **Intervention:** Participants with TBI were randomized into two groups and received the dance intervention either during the first 3- month phase (AB group) or the second 3-month phase (BA group). The Dual-Assisted Dance Rehabilitation (DARE) featured a combination of dance training and specialized physical therapy, and was provided for 60mi/d, 2d/wk, for 12wk. Outcome measures were assessed at the 3- and 6-mo stages. **Outcome Measures:** Trunk impairment scale (TIS), Berg Balance Scale (BBS), Action Research Arm Test (ARAT), Montreal Cognitive Assessment (MoCA), Frontal Assessment Battery (FAB), Wechsler Adult Intelligence Scale (WAIS-IV), Sustained Attention to Response Test (SART), Behaviour Rating Inventory of Executive Functioning – adult version (BRIEF-A), Beck Depression Inventory (BDI-II), Quality of Life (QOLIBRI).	1. Quality of life, as measured by the QOLIBRI was not significantly improved after the intervention (p=.977).
	Yoga	
Donnelly et al. (2021) USA Pre-Post N=857	**Population:** ABI; TBI=705; Mean Age=43yr; Gender: Male=173, Female=530, Not Reported=2; Mean Time Post Injury=4.8yr; *Caregivers* (n=152); Mean Age=49yr; Gender: Male=23, Female=129. **Intervention:** Participants with a TBI and caregivers received a yoga program (*LoveYourBrain)* with psychoeducation, involving didactic material, question prompts, and skill-building exercises in resilience and community connection. The program was offered for 90min, 1/wk for 6wk. **Outcome Measures:** Neurology Quality-of-Life (Neuro-QOL), Quality of Life After Brain Injury overall scale (QOLIBRI-OS), Resilience, Cognition, Positive Affect and Well-being, Traumatic Brain Injury Quality of Life (TBI-QOL).	1. All participants showed significant improvements in their scores on the QOLIBRI-OS, resilience, cognition and positive affect and well-being measures (p<.0000) from baseline to post-intervention. 2. No significant improvements were observed in emotional and behavioral dysregulation over time (p=.9997). 3. For the QOLIBRI-OS, there was a significant interaction between people 55 and 70 years of age and time (p= 0.007), suggesting that the positive impact of *LoveYourBrain* Yoga on quality of life may be less for older people as compared to younger people.

Discussion

In an RCT, Williams et al. (2022) compared a ballistic resistance exercise to non-ballistic resistance training that included balance exercises, lower limb stretching, strengthening exercises, cardiovascular fitness training and gait training. The authors found no significant differences between groups in health-related quality of life (Williams et al., 2022). In an RCT crossover, Sarkamo et al (2021) examined the benefits of dance rehabilitation. Participants received dance rehabilitation, including a combination of dance training and specialized physical therapy. The authors found no significant differences in quality of life, as measured by the QOLIBRI was after the intervention (Sarkamo et al., 2021).

In a pre-post study by Donnelly et al. (2021), individuals with TBI and their caregivers received yoga sessions, that included 10 minutes of breathing exercises, 45 minutes of gentle yoga, and 15 minutes of guided meditation. Yoga sessions aimed to improve attention control, emotional regulation, and self-efficacy. Participants reported high levels of satisfaction with the program and significant improvement in quality of life, positive affect and wellbeing, and cognitive measures were observed.

Conclusion

There is 1a evidence (Sarkamo et al., 2021) that dance rehabilitation may not improve quality of life in individuals with moderate to severe TBI.

There is 1b evidence (Williams et al., 2022) that ballistic exercise training may not improve quality of life in individuals with TBI.

There is level 4 evidence (Donnelly et al., 2021) that a yoga intervention may improve quality of life post ABI, particularly for younger people.

KEY POINTS

- Dance rehabilitation may not improve quality of life post TBI.
- Ballistic exercise training may not improve quality of life in individuals with TBI, when compared to non-ballistic exercise.
- A yoga intervention may improve quality of life post ABI, particularly for younger individuals.

Music Therapy

Music therapy has been used in rehabilitation of brain injuries to stimulate brain function, and it usually involves listening to music, singing, composition, performing or creating music on an

instrument, improvising music or the combination of musical activities with other forms of art (Magee et al., 2017).

TABLE 17 | Music Therapy for Life Satisfaction and Quality of Life Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Siponkoski et al. (2022) Finland RCT Crossover PEDro=5 $N_{initial}$=40 N_{final}=38	**Population:** TBI; *AB Group* (n=20); Mean age=41.6yr; Gender: Male=10, Female=10; Mean GCS=12.3; Time Post Injury=8.6mo. *BA Group* (n=18); Mean Age=41.8yr; Gender: Male=12, Female=6; Mean GCS=10.9; Time Post Injury=9mo. **Intervention:** Participants were randomized into two groups (AB and BA). For the duration of the first 3mo, the AB group received neurological music therapy in addition to standard care, whereas the BA group received only standard care. Both groups received treatment for 60 min/d, 2d/wk and switched. halfway through the study period after 3mo. Outcome measures were assessed at 3, 6, and 18mo. **Outcome Measures:** Behaviour Rating Inventory of Executive Function- Adult version (BRIEF-A), Quality of Life after Brain Injury (QOLIBRI), Global Executive Composite Index (GECI), Beck Depression Inventory II (BDI-II).	1. No significant group differences were found in quality of life, as measured by the QOLIBRI (p=.407).

Discussion

An RCT by Siponkoski et al. (2022) examined the effectiveness of a neurological music therapy intervention, in addition to standard care, for the rehabilitation of cognition in individuals with TBI, particularly executive function, memory and attention. No significant group differences were found in quality of life, as measured by the Quality of Life after Brain Injury (QOLIBRI).

Conclusions

There is 2 evidence (Siponkoski et al., 2022) that neurological music therapy may not improve quality of life in individuals who have sustained a moderate to severe TBI.

KEY POINTS

- Music therapy may not improve quality of life post TBI.

Cognitive Interventions

Individuals with moderate to severe TBI often experience cognitive difficulties related to memory, attention, information processing and executive function, as well as social cognition (Azouvi et al., 2017). Cognition deficits can impact all aspects of the person's life, including their relationships with others; for instance, impairments related to social cognition such as problems navigating social situations and responding to emotional stimuli, can lead to poor social integration (McDonald, 2013).

TABLE 18 | Cognitive Interventions for Life Satisfaction and Quality of Life Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Cicerone et al. (2008) USA RCT PEDro=6 N=68	**Population:** TBI; Gender: Male=46, Female=22; Severity: Severe=40, Moderate=16, Mild=9, Unknown=3. *Treatment Group (n=34):* Mean Age=38.7yr; Mean Time Post Injury=49.6mo. *Control Group (n=34):* Mean Age=34.5yr; Mean Time Post Injury=37 mo. **Intervention:** Patients were randomly assigned to an Intensive Cognitive Rehabilitation Program (ICRP, treatment) or a standard neurorehabilitation program (control). ICRP received holistic neuropsychological rehabilitation in cognitive, emotional, interpersonal, and functional interventions, and controls received discipline-specific therapies. All participants received 15 hr/wk for 16 wk. **Outcome Measures:** Community Integration Questionnaire (CIQ), and Perceived Quality of Life scale (PQOL), Trail Making Test-A, Trail Making Test-B, Controlled Oral Word Association Test (COWAT), Booklet Category Test (BCT), California Verbal Learning Test-II (CVLT-II), Rey Complex Figure, Vocational Integration Scale.	1. The treatment group had significant increases on CIQ total (p=0.004), PQOL (p=0.004) and Self efficacy (p=0.024) compared to controls post treatment.
Afsar et al. (2021) India Pre-Post N=12	**Population:** Severe TBI; Mean Age=32.33yr; Gender: Male=9, Female=3; Mean Time Post- Injury=11.37mo. **Intervention:** Individuals received a cognitive retraining (CR) intervention that aimed at improving processing speed, attention, executive function, learning and memory. Perceived stress and quality of life were also assessed. Participants received 20 sessions, 3/wk for 2mo. **Outcome Measures:** NIMHANDS Neuropsychology Battery; Rivermead Post-Concussion Symptoms Questionnaire (RPCSQ); Perceived Stress Scale; Visual Analog Scale (VAS); World Health Organization Quality of Life Scale-Brief (WHOQ).	1. Significant improvements were found in quality of life, as measured by the WHOQoL scale, in the psychological domain (p=.034).

Discussion

In an RCT, Cicerone et al. (2008) examined the effectiveness of an intensive cognitive rehabilitation program that integrated cognitive, interpersonal and functional interventions. The authors found that participants had higher perceived quality of life and community integration than those receiving standard neurorehabilitation (Cicerone et al., 2008). Similarly, in a pre-post study, Afsar et al. (2021) found that a cognitive retraining intervention improved quality of life in individuals with severe TBI.

Conclusion

There is level 1b evidence (Cicerone et al., 2008) that an intensive cognitive rehabilitation program may improve community integration and perceived quality of life compared to standard neurorehabilitation in individuals with TBI.

There is level 4 evidence (Afsar et al., 2021) that a cognitive retraining (CR) intervention may improve quality of life in individuals with severe TBI.

KEY POINTS

- Cognitive interventions may improve quality of life and community integration in individuals with moderate to severe TBI.

Technology Interventions

The use of technology, including wearable devices, virtual reality and web-based tools, in the delivery of care has the potential to improve rehabilitation services for patients living with a variety of conditions, such as musculoskeletal diseases, stroke and traumatic brain injury (Edwards et al., 2022). For those with brain injuries, services such as telerehabilitation can facilitate access to care by easing the burden of transportation and costs for individuals and families and limiting the number of missed appointments (Subbarao et al., 2021).

TABLE 19 | Technology Interventions for Life Satisfaction and Quality of Life Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Bergquist et al. (2022) USA RCT PEDro=7 $N_{initial}$=332 N_{final}=278	**Population:** TBI; *Remote Group* (n=166); Median Age=59.7yr (IQR 18.6-89.4); Gender: Male=88, Female=78; Time Post Injury=15.9wk. *Usual care* (n=166); Median Age=59.3yr (IQR 18.6-93.6); Gender: Male=100, Female=66; Time post-injury=15.3wk. **Intervention:** Participants were randomly assigned into remote care, using *Care Hubs*, a web-based community, or usual care. Participants in the remote care group received a behavioral intervention that included remote clinical guidance from clinicians, education, links to community resources and support for participants and their families. **Outcome Measures:** Activity measure post-acute care (AM-PAC), Quality of life post-TBI (TBI-QOL), Clinical Satisfaction and Competency Rating scale (CSCRS).	1. No significant group changes were found for the TBI-QOL between baseline and endpoint. 2. There were no significant group differences on any TBI-QOL item.
Corallo et al. (2022) Italy RCT PEDro=7 N=12	**Population:** Severe ABI; TBI=58.3%, Vascular=41.7%; *Experimental group* (n=6); Mean Age=46.7yr; Gender: Male=3, Female=3; *Control group* (n=6); Mean Age=47.2yr; Gender: Male=4, Female=2; Mean Time Post Injury=Not reported. **Intervention:** Individuals with severe ABI underwent neurorehabilitation to address motor, psycho-cognitive and sensory deficits. In the experimental group, the treatment was performed by using a humanoid robot. The robot provides feedback by a combination of verbal response and visual feedback. Rehabilitation was delivered for 60min, 3 sessions per wk, for 8wk. Outcomes were assessed on admission (T0), after 1mo (T1), and after 2mo (T2). **Outcome Measures:** Severe impairment Battery (SIB), Level of Cognitive Functioning Scale (LCF), Mini Mental State Exam (MMSE), Hamilton Rating Scale for Anxiety (HAM-A), Beck Depression Inventory (BDI-II); Functional Independent Measure scale (FIM), EuroQol-5D (EQ-5D).	1. Time significantly affected the patients' scores from baseline to T1 for EQ-5D (p<.001). 2. The experimental treatment had a higher effect than the traditional one on quality of life, as measured by the EQ-5D (p =.04). 1. While participants in the experimental group did not improve in their cognitive performance, their perceived mood and quality of life were better than the control group.
Mendes et al., (2021) Portugal RCT PEDro=6 N=27	**Population:** TBI; *Experimental group (EG)* (n=8); Mean Age=37yr; Gender: Male=8, Female=0; Mean GCS= 6, Time Post Injury Mean=5.09 mo. *Control Group I (CGI)* (n=10); Mean Age=37.2yr; Gender: Male=8, Female=2; Mean GCS=9, Time Post Injury Mean=53 mo. *Control Group II (CGII)* (n=9); Mean Age: 39.4yr; Gender: Male=6, Female=3; Mean GCS= 7; Time Post Injury= 1.66mo. **Intervention:** Participants received a remote holistic neuropsychological intervention program supported by a VR platform. The intervention included a 40-60 min session 5x/ wk for 16 wk (cognitive training 3x/ wk and psychosocial 2x/wk). Control Group I received	1. For the QOLIBRI, there were no significant intragroup differences in EG and CGI (both p>0.348), but there were significant intergroup differences (p=0.035 in the pre-test and p=0.038 in the post-test between EG and CGI). 2. CGII had significant intragroup difference (p=0.024) between the pre-test and post-test. Intergroup analyses between EG and CGII revealed nearly significant differences at the pre-test assessment (p = .073) but not at the post-test assessment (p = .332). 3. No effect was found between groups for quality of life, as measured by the QLIBRI.

Author Year Country Study Design Sample Size	Methods	Outcome
	conventional holistic neuropsychological intervention program) for 22hr/ wk x22 wk. Control Group II did not receive any intervention. **Outcome Measures:** Montreal Cognitive Assessment (MoCA), Hospital Anxiety and Depression Scale (HADS), Quality of Life after Brain Injury (QOLIBRI); Token Test (TT), Wisconsin Card Sorting Test (WCST), Trail Making Test A, Trail Making Test B, Hopkins Verbal Learning Test (HVLT), Weschler Memory Scale-III (WMS-III), Stroop Test.	

Discussion

In an RCT, Bergquist et al. (2022) examined the effectiveness of a behavioral intervention using *Care Hubs*, a web-based community, compared to usual care in a TBI population. The intervention included clinical guidance and education delivered remotely by clinicians, with links to support resources in the community. In this study, no differences between groups in terms of quality of life as measured by the Quality of life post-TBI (TBI-QOL) were observed. The effectiveness of rehabilitation via remote care was also examined in the study by Mendes et al. (2021). The authors implemented a virtual reality platform to deliver a neuropsychological intervention.

In the study by Corallo et al. (2022), participants with ABI received neurorehabilitation of motor, psycho-cognitive and sensory deficits with assistance of a humanoid robot that provided visual and vernal feedback. The authors found that participants in the experimental group showed higher quality of life as measured by the EuroQol-5D (EQ-5D), when compared to traditional rehabilitation. The authors found some intergroup differences, but no differences between groups were observed in term of quality of life, as measured by the Quality of Life after Brain Injury (QOLIBRI).

Conclusions

There is level 1b evidence (Bergquist et al., 2022) that a web-based community resource (Care Hubs) may not improve perceived quality of life in individuals with TBI, when compared to usual care.

There is level 1b evidence (Corallo et al., 2022) that assistance of a humanoid robot in the delivery of neurorehabilitation may improve quality of life post ABI.

There is level 1b evidence (Mendes et al., 2021) that remote holistic neuropsychological program by a VR platform may not be effective for improving quality of life and psychosocial function.

KEY POINTS

- The use of remote web-based resources or virtual reality platforms for the delivery of rehabilitation may not improve quality of life, when compared to usual care post moderate to severe TBI.
- Assistance from a humanoid robot in the delivery of neurorehabilitation to individuals with ABI may improve quality of life.

Vocational Rehabilitation and Productivity

Return to work is key for quality of life and life satisfaction post brain injury; however, individuals may often encounter challenges that may result in job instability and unemployment (Tyerman, 2012). After an ABI, individuals may present with long-lasting difficulties that may impact participation in work-related activities, these impairments are commonly considered 'invisible' and may lead to misunderstandings with employers and colleagues, as well as unrealistic expectations at the workplace (Karcz et al., 2022). Vocational rehabilitation is a process in which individuals living with illness or disability can be enabled to access, maintain and return to a meaningful occupation, such as work or education (Chamberlain et al., 2009).

Vocational rehabilitation for individuals with ABI involves addressing multiple factors related to the person and, the job demands and the environment; for instance, the age of the individual, level of education and the type of pre-injury occupation (Murray et al., 2022). Brain injury can deprive individuals from participating in gainful and challenging employment and achieving social and financial stability; in addition, depression and anxiety are more common among individuals who are unable to return to work or who cannot find work post ABI (McCrimmon & Oddy, 2006; Ponsford & Spitz, 2015). This section will discuss studies examining methods of vocational rehabilitation for individuals with ABI including technology, cognitive training, mentorship, community rehabilitation, resource facilitation, and multimodal therapies.

Cognitive Interventions

Given that individuals with brain injuries often present with difficulties with cognitive processing, assessment and rehabilitation of cognition is critical to enable the individual to return to work (Mani et al., 2017). Cognitive interventions are some of the most commonly studied rehabilitative interventions

for individuals with ABI due to the high prevalence of cognitive impairments within this clinical population (Vanderploeg et al., 2008).

TABLE 20 | Cognitive Interventions for Vocational Rehabilitation and Productivity Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Man et al. (2013) Hong Kong RCT PEDro=5 N=40	**Population:** TBI; *Artificial Intelligence Group (n=20):* Mean GCS=10.25. *Psychoeducational Group (n=20):* Mean GCS=10.05. **Intervention:** Patients were randomly assigned to 12 sessions of Artificial Intelligence Virtual Reality for problem-solving training (treatment) or a conventional psychoeducational program (control). Outcomes were assessed at 1, 3 and 6 mo. **Outcome Measures:** Wisconsin Card Sorting Test–computer version 4 (WCST), Tower of London Test, Vocational Cognitive Rating Scale, Employment status.	1. Participants in the treatment group performed better across all measures, but only WCST-errors (p=0.02) and WCST-conceptual level response (p<0.01) were statistically significant. 2. Both groups showed significant improvements in employment outcomes (p=0.04 and p=0.018, respectively), but there were no significant differences between groups. 3. The treatment group showed significant improvement in self-efficacy (p=0.018) from pre- to post-test, but the control group did not. However, there was no significant difference between the two groups.
Vanderploeg et al. (2008) USA RCT PEDro=7 N=360	**Population:** TBI; Mean Age=32.4yr; Gender: Male=335, Female=25. **Intervention:** Patients were randomly assigned to specific cognitive-didactic therapy (n=180) or functional-experiential rehabilitation therapy (n=180) for 1.5-2.5 hr/d over 20-60 days. **Outcome Measure:** Return to work/school, Return to Work/School, Functional Independence Measure (FIM), Disability Rating Scale (DRS), Present State Examination (PSE), Apathy Evaluation Scale, Neurobehavioral Rating Scale, Rancho Los Amigos Scale (RLAS).	1. Return to work at 1yr post intervention for the cognitive group and functional group was 38.9% and 35.4%, respectively. The difference between groups was not significant (p=0.50).
Cicerone et al. (2008) USA RCT PEDro=6 N=68	**Population:** TBI; Gender: Male=46, Female=22; Severity: Severe=40, Moderate=16, Mild=9, Unknown=3. *Treatment Group (n=34):* Mean Age=38.7yr; Mean Time Post Injury=49.6mo. *Control Group (n=34):* Mean Age=34.5yr; Mean Time Post Injury=37 mo. **Intervention:** Patients were randomly assigned to an Intensive Cognitive Rehabilitation Program (ICRP, treatment) or a standard neurorehabilitation program (control). ICRP received holistic neuropsychological rehabilitation in cognitive, emotional, interpersonal, and functional interventions, and controls received discipline-specific therapies. All participants received 15 hr/wk for 16 wk. **Outcome Measures:** Community Integration Questionnaire (CIQ), and Perceived Quality of Life scale	1. The treatment group had significant increases on CIQ total (p=0.004), PQOL (p=0.004) and SES (p=0.024) compared to controls post treatment. 2. Employment post treatment was acquired by 47% of the treatment group compared to 21% of controls. 3. Controls were more likely to receive continued comprehensive treatment after the study than the treatment group (p=0.001).

Author Year Country Study Design Sample Size	Methods	Outcome
	(PQOL), Trail Making Test-A, Trail Making Test-B, Controlled Oral Word Association Test (COWAT), Booklet Category Test (BCT), California Verbal Learning Test-II (CVLT-II), Rey Complex Figure, Vocational Integration Scale.	
Salazar et al. (2000) USA RCT PEDro=6 N=120	**Population:** TBI; *Hospital Group:* Mean Age=25yr; Gender: Male=62, Female=5; Mean Time Post Injury=38 days; Mean GCS=9.4. *Home Group:* Mean Age=26yr; Gender: Male=51, Female=2; Mean Time Post Injury=39 days; Mean GCS=9.5. **Intervention:** Patients were randomly assigned to intensive in-hospital cognitive rehabilitation (8 wk) or limited home rehabilitation. **Outcome Measure:** Return to work and/or military duty, Return to work/duty, Katz Adjustment scale (KAS), Halstead-Reitan Neuropsychological Impairment Index, Buschke Selective Reminding Test, Trahan Continuous Visual Memory Test, Paced Auditory Serial Addition Test, Wisconsin Card Sorting, Wechsler Memory Scale Revised, Auditory Consonant Trigrams.	1. Return to work was achieved by 90% of the hospital group and 94% of the home group; there was no significant difference between groups (p=0.51). 2. After the intervention, 73% of the hospital group and 66% of the home group were fit for active military duty; there was no significant difference between groups (p=0.43).
Schoenberg et al. (2008) US Case Control N=39	**Population:** TBI; Teletherapy (TELE) Group (n=19): Mean Age=27.4yr; Gender: Male=18, Female=1; Mean Time Post Injury=58.7mo; Severity: Moderate-to-severe=19; Face-to-Face (FTF) Reference Group (n=20): Mean Age=33.1yr; Gender: Male=15, Female=5; Mean Time Post Injury=29.4mo; Severity: Moderate-to-Severe=20 **Intervention:** Participants in the TELE group received computer-based cognitive rehabilitation program via computers connected to the Internet at their home. The teletherapy program included individual exercises, ranging from simple attention and executive tasks to complex visuospatial memory tasks, as well as complex problem-solving and decision-making exercises. Participants in the FTF group received a minimum of six sessions of face-to-face outpatient cognitive and speech–language rehabilitation therapy. **Outcome Measures**: Independent living status, independent driving, return to work or school, total cost of the treatment and a measure of service costs per hour, hours of therapy.	1. There were no participants in the TELE group or the FTF group who were working or attending school, living independently, or driving at the start of the study. 2. Within-groups analysis of change from baseline to post-intervention revealed that the proportion of participants living independently, driving, and working significantly improved for both groups (p<.01). 3. There were no significant differences between groups in the proportion of participants living independently, driving, or returning to school or work at the conclusion of intervention (p>.05).

Discussion

In an RCT, Vanderploeg et al. (2008) compared two different treatment approaches for vocational rehabilitation, cognitive-didactic therapy, and functional-experiential rehabilitation therapy. After one

year of cognitive-didactic therapy, over one third of participants had returned to work, but this was similar to participants in the functional treatment arm (Vanderploeg et al., 2008). In an RCT study, Salazar et al. (2000) evaluated the effect of an in-hospital cognitive rehabilitation program compared to a limited home rehabilitation program on return to employment and fitness for military duty. There were no significant differences between groups in terms of the number of participants who returned to work or were fit for active duty (Salazar et al., 2000). Although there was no difference between the treatment and control groups, Salazar et al. (2000) reported high employment rates (90% and 94%, respectively); this was likely due to the study being conducted during the acute phase of recovery, which may have reduced the potential impact that the intervention could have had due to spontaneous recovery. In an RCT, Cicerone et al. (2008) examined an Intensive Cognitive Rehabilitation Program (ICRP, treatment), that included holistic neuropsychological rehabilitation in cognitive, emotional, interpersonal, and functional interventions. The authors found that 47% of individuals in the treatment group acquired employment, compared to 21% of controls (Cicerone et al., 2008).

Two studies assessed cognitive interventions delivered using technology. Man et al. (2013) evaluated the effect of technology on problem-solving rehabilitation and reported greater improvements in employment outcomes in participants receiving virtual reality problem-solving training compared to individuals receiving a conventional psychoeducational program, although this difference was not statistically significant (Man et al., 2013). Schoenberg et al. (2008) examined the use of computer-based cognitive rehabilitation program via computers connected to the Internet at the patient's home. The authors found no significant differences regarding return to work or school.

Conclusions

There is level 1b evidence (Vanderploeg et al., 2008) that cognitive-didactic therapy may not be more effective than functional-experiential rehabilitation therapy for facilitating return to work in individuals post TBI.

There is 1b level of evidence (Cicerone et al., 2008) that a holistic cognitive rehabilitation program may improve employment rate among individuals with TBI.

There is level 1b evidence (Salazar et al., 2000) that intensive hospital-based cognitive rehabilitation may not improve return to work compared to limited home-based rehabilitation in individuals post TBI.

There is level 2 evidence (Man et al., 2013) that artificial intelligence virtual reality problem-solving training may not improve employment outcomes compared to a conventional psychoeducational program in individuals post TBI.

There is level 3 evidence (Schoenberg et al., 2018) that computer-based cognitive rehabilitation programs and face-to-face cognitive rehabilitation programs may be equally effective in improving return to work and/or school in individuals with moderate-to-severe TBI.

KEY POINTS

- Cognitive rehabilitation therapy may not be effective for improving employment rates in individuals with TBI.

Educational Interventions

Individuals interested in returning to post-secondary education following ABI can face many potential challenges. Educational interventions provide an opportunity for individuals with ABI to learn more about the potential challenges encountered following a brain injury, as well as the resources that are available to them. To date, few studies have examined educational interventions for vocational rehabilitation following ABI.

TABLE 21 | Education for Vocational Rehabilitation and Productivity Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
MacLennan & MacLennan (2008) USA Case-Series N=3	**Population:** TBI; Gender: Male=3, Female=0; Mean Age=23.6 yr. **Intervention:** Individuals participated in a simulated college experience: 16 sessions (1 hr), 12 lectures, and 4 exams testing their ability to learn. **Outcome Measure:** Return to work/school.	1. Performance in the college simulation was helpful in predicting success and challenges in college performance.

Discussion

In a case series, MacLennan & MacLennan (2008) assessed a simulated college experience and its ability to predict college performance and success in individuals with a TBI. Both participants who performed poorly did not return to school, while one participant who was successful in the program did return to school. One participant specifically chose not to return to school after the simulated lectures despite initially insisting that he would; the experience may have led to an increased awareness of impairment. Exposing individuals with TBI to a simulated college experience may help the individual in making a more informed decision about pursuing further education; however, more studies with bigger samples are needed to evaluate the effectiveness of this program as well as other educational interventions.

Conclusions

There is level 4 evidence (MacLennan & MacLennan, 2008) that a simulated college experience may predict readiness for post-secondary education in individuals post TBI.

KEY POINTS

- Simulated educational experiences may be helpful for predicting an individual's readiness to return to school post TBI.

Mentorship Programs

Mentorship provides an individual with a trained mentor or peer to help with the transition to living with an ABI. One-to-one mentoring has the potential to improve community reintegration and may be useful to address the individual's needs; however there is limited evidence on the effectiveness of peer mentorship for those who have sustained brain injuries (Morris et al., 2017).

TABLE 22| Mentorship Programs for Vocational Rehabilitation and Productivity Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Curl et al. (1996) USA Case Series N=9	**Population:** TBI=9; Mean age= 34yr; Gender: Male=8, Female=1; Mean Time Post Injury=>1yr; Severity: Severe=9. **Intervention:** Participants took part in a vocational rehabilitation program that focused on utilizing coworkers as trainers in the work environment. Coworkers provided regular performance feedback using a "tell, show, watch, coach" approach, and provided worker-implemented tools as necessary to resolve performance deficits. **Outcome Measures:** Employment status, job placement, salary, coworkers' abilities to work with and mentor participants with TBI.	1. Seven of the 9 participants were employed at the time of the program evaluation. 2. Coworker trainers learned to apply the basic teaching sequence and basic organizational tools. 3. The coworker training model was assistive for approximately one third of the participants.

Discussion

In a case series, Curl et al. (1996) examined the effectiveness of an intervention with coworkers of participants with TBI as trainers in the work environment. The authors and found that the co-worker training model was assistive to approximately one third of the study participants (Curl et al., 1996).

Mentorship may be effective for increasing post-ABI vocational performance; however, there is limited research.

Conclusions

There is level 4 evidence (Curl et al., 1996) that a model where coworkers act as trainers in the work environment may improve vocational outcomes in individuals with severe TBI.

KEY POINTS

- Mentorship in the community or at the workplace may be effective for improving employment and education rates post ABI.

Community-based Rehabilitation

Participation in the labour market is essential for social inclusion, economic benefit and well-being; however, returning to work may be challenging for individuals who have sustained a brain injury (Karcz et al., 2022). Community-based rehabilitation plays an important role in shaping return to work/school outcomes in individuals post ABI. Vocational rehabilitation within the community setting requires the collaboration between diverse health, social, and educational service agencies.

TABLE 23| Community-based Rehabilitation for Vocational Rehabilitation and Productivity Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Klonoff et al. (2001) USA Case Series N=164	**Population:** Severe=60.8%; TBI=113, Stroke=38, Other=13; Mean Age=33.6yr; Gender: Male=108, Female=56; Mean Time Post Injury=13.9 mo. **Intervention:** Follow up of participants in a work/school re-entry program at the Adult Day Hospital for Neurological Rehabilitation (ADHNR). **Outcome Measure:** Rates of productivity depending on return to work/school.	1. Of the participants who were productive pre-injury, 25.3% were engaged in the same line of work/school at the same capacity at follow-up. 2. Eleven percent returned to the same job as pre-injury with modifications and 38.3% returned to a different job or school level (mostly lower) or in volunteer or homemaker positions. 3. Those working/in school at follow up were significantly younger than the non-productive group (p=0.009).
Malec & Moessner (2000) USA Post-Test N=62	**Population:** TBI=48, ABI=14; Mean Age=34.8yr; Gender: Male=48, Female=14; Severity: Mild=2, Moderate=1, Severe=37, Undetermined=22; Median Time Post Injury=679 days.	1. Those with mild impaired self-awareness (ISA) showed a decline in ISA on the MPAI from 37% to 29%, and those with moderate to severe ISA declined from 58% to 29%.

Author Year Country Study Design Sample Size	Methods	Outcome
	Intervention: Patients completed a brain injury comprehensive day treatment program. Outcomes were evaluated at the end of the program and at 1yr follow-up. **Outcome Measure:** Mayo-Portland Adaptability Inventory (MPAI), Vocational Independence Scale (VIS), Independent Living Scale (ILS), Goal Attainment Scaling (GAS).	Overall change after 1yr was found to be significant (p<0.001). 2. ISA accounted for 23.7% of the variance in GAS scores (p<0.00). 3. ISA contributed significantly to the prediction of ILS (p<0.01). 4. There was no significant difference in VIS outcome at 1yr.
Wall et al. (1998) USA Post-Test N=38	**Population:** TBI=31, Stroke=3, Other=4; Mean Age=35.38yr; Gender: Male=28, Female=10; Mean Time Post Injury=8.91yr; Severity: Severe=90%. **Intervention:** Patients attended a 16 wk Community Based Training Program (CBTP) that combined work adjustment and supported employment concepts. Outcomes were assessed after treatment and at follow-up. **Outcome Measure:** Employment status, Modified Job Diagnostic Survey (mJDS).	1. Fifty-eight percent of patients completed the program. Those who completed the program had a longer length of disability and longer pre-injury work histories than those who did not complete it (p<0.05). 2. Mean time from program completion to follow-up was 18.67mo, at which point 38% were employed. 3. More than one placement was required by 14% of the sample to secure employment and 14% were still in the placement process. 4. Of those who completed the program, 59% were competitively employed, 24% were unemployed, and 18% were still in the placement process.
Buffington & Malec (1997) USA Pre-Post N=80	**Population:** TBI=52, ABI=27; Median Age=37yr; Gender: Males=50, Females=30; Mean Time Post Injury=64mo; Severity: Mild=10, Moderate-Severe=35, Unknown=7. **Intervention:** Patients received vocational services and assistance through inpatient or outpatient rehabilitation with follow-up 90 days after occupational placement. **Outcome Measure:** Vocational Outcome Scale (VOS).	1. At 3mo, almost 40% were placed, with the majority placed in independent competitive work (VOS level 5). 2. At 1yr, about 70% of all participants were placed. 3. Of those placed by 1yr, 74% were in community-based employment (VOS levels 3-5), of which 41% were placed into independent work (VOS level 5). 4. Of all placements made, 37% were returning to work with the same employer as preinjury, but not necessarily the same job. 5. Those entering the program at <12mo post injury had significantly faster (3.68 vs. 6.0mo) and better (VOS score of 4.48 vs. 3.74) job placements than those entering the program >12mo post injury (p<0.05).

Author Year Country Study Design Sample Size	Methods	Outcome
Wehman et al. (1993) Pre-Post USA N=80	**Population:** TBI=80; Mean Age=30.9yr; Gender: Male=82.5%, Female=17.5%; Severity: Severe=80; Mean Time Post Injury=6.1yr **Intervention:** Participants received supported employment intervention, which involved job development, job placement, job site training, and job retention services provided by job coaches. The intervention was provided over a number of weeks or months until the participants' job performance was stabilized. **Outcome Measures**: Hr worked, type of occupation, earnings, job retention, monthly employment ratio, intervention hr required from job coaches.	1. Participants' monthly employment ratio increased from 13% after injury with no supported employment to 67% with supported employment services (a ratio of 100% indicates continuous employment). 2. The majority of participants were employed in warehouse (23.7%), clerical (19.5%), and food service-related occupations (16.9%). 3. An average of 249.1h was required from job coaches to train and provide follow-up services to program participants.
Wehman et al. (1989) USA Pre-Post N=20	**Population:** Severe TBI=20; Age Range=18-64yr; Gender: Male=18, Female=2; Mean Time Post Injury=Not reported. **Intervention:** Participants received supported employment intervention, which involved job development, job placement, job site training, and job retention services provided by job coaches. The intervention was provided over several weeks or months until the participants' job performance was stabilized. **Outcome Measures**: Job placement outcomes (wages, hr worked, length of employment and type of occupation, direct behavioral observation of work performance, a 5-point Likert scale form on the participants' work habits completed by employers, monthly employment ratio.	1. The mean number of hours worked per person for supported employment intervention was 278hr. 2. Employment ratios improved significantly after the intervention ($p<.001$)
Wehman et al. (1989) USA Case Series N=5	**Population**: Severe TBI; Mean Age=30yr; Gender: Male=5. **Intervention:** Participants received supported employment intervention, which involved job development, job placement, job site training, and job retention services provided by job coaches. The intervention was provided over a number of weeks or months until the participants' job performance is stabilized. **Outcome Measures**: Wages earned per week, hr worked per week, Staff intervention hr and costs of the program, supervisors' levels of satisfaction with participants' job performance rated on a 5-point scale, with 1 indicating extreme dissatisfaction and 5 indicating extreme satisfaction.	1. The range of hours worked per week varied from 15 to 40. 2. Participants required 339hr of job coach intervention time on average. 3. Employers were generally satisfied to very satisfied with participants' job performance, with the mean supervisor ratings ranging from 3.1 to 4.3 on a scale of 1-5.

Author Year Country Study Design Sample Size	Methods	Outcome
Wehman et al. (1988) Post-Test USA $N_{Initial}$=32, N_{Final}=15	**Population:** Severe TBI=32; Mean Age=29yr; Gender: Male=90.6%, Female=9.4%; Mean Time Post Injury=Not reported. **Intervention**: Participants were clients who received supported employment intervention over the course of 5yr. The intervention involved job development, job placement, job site training, and job retention services provided by job coaches. Participants had received an average of 266h of intervention at the time of the program evaluation. The intervention was still ongoing as of the writing of the article. **Outcome Measures:** hours worked, type of occupation, job retention, length of employment, staff intervention hours required.	1. Fifteen of the participants had been placed in competitive employment. 2. Participants gained employment in warehouse (31.5%), clerical (31.5%), and human service-related occupations (19%). 3. Mean hours worked per week was approximately 31h. 4. Eleven of 15 participants were still working as of the writing of the article, making up a job retention rate of 73.4%. 5. The mean length of employment was 9mo as of the writing of the article. 6. The percentage of the intervention hours that required assistance from job coaches saw a steady decline, from an initial percentage level of approx. 90% over the first 7wk of placement to less than 10% at 28wk.

Discussion

Community rehabilitation provides an opportunity for individuals to reintegrate themselves gradually into the community. Klonoff et al. (2001) the effectiveness of a work/school re-entry program, and reported that at 20-week follow-up, a minority of individuals returned to work in the same field and at the same pre-injury capacity. The Community Based Training Program was evaluated in a post-test study by Wall et al. (1998). The program was completed by 58% of participants and, of those, more than half were competitively employed. Those who completed the program often had a longer length of disability and longer employment pre-injury (Wall et al., 1998). Longer employment prior to injury may be associated with an older population in the study, indicating that younger individuals with a shorter pre-injury employment history may have recovered more quickly. In a different study, the effect of a comprehensive brain injury day treatment program was evaluated, which showed no significant improvement in vocational independence at one year follow-up compared to at the end of the program (Malec & Moessner, 2000).

To meet vocational goals post ABI, access to supported employment services may be essential. This was illustrated in four studies that assessed the effectiveness of a supported employment intervention, which involved job development, job placement, job site training, and job retention services provided by job coaches (Wehman, Kreutzer, et al., 1989; Wehman et al., 1988; Wehman et al., 1993; Wehman, West, et al., 1989). The research team evaluated the program at four different time points during a five-

year period and, in all four studies, positive vocational outcomes were observed in program participants with TBI. Specifically, eighty participants with ABI were able to obtain competitive employment during the five-year period, and the participants required less assistance and training from job coaches as the intervention went on (Wehman, Kreutzer, et al., 1989; Wehman et al., 1988; Wehman et al., 1993; Wehman, West, et al., 1989). In addition, employers voiced their satisfaction with participants' overall job performance (Wehman et al., 1993; Wehman, West, et al., 1989)

Buffington & Malec (1997) saw 40% of their participants placed in jobs at 3 months, and at 1 year 70% of the participants were placed. The authors also reported that early onset vocational training (<12 mo) is more effective than later onset training. Community-based rehabilitation may be effective in improving vocational outcomes post ABI stroke, but a lack of control groups in most studies to date makes it difficult to accurately determine treatment effects.

Conclusions

There is level 4 evidence (Malec & Moessner, 2000; Wall et al., 1998) that community-based programs may improve return to work in individuals post ABI.

There is level 4 evidence (Buffington & Malec, 1997; Klonoff et al. 2001) that vocational services and work/school re-entry programs may improve vocational outcomes in individuals with TBI.

There is level 4 evidence (Wehman, Kreutzer, et al., 1989; Wehman et al., 1993; Wehman, West, et al., 1989b; Wehman et al., 1988) that supported employment interventions may improve vocational outcomes in individuals with severe TBI.

KEY POINTS

- Community-based vocational rehabilitation may improve employment outcomes post ABI.

Resource Facilitation

Resource facilitators provide support for transitioning back into the community for individuals with an ABI. They provide a comprehensive explanation of available resources for individuals with an ABI, as well as how to access them (Trexler et al., 2010). Resource facilitators help individuals with brain injuries access information, services and supports, as well as assistance navigating systems (Trexler & Parrot, 2018).

TABLE 24 | Resource Facilitation for Vocational Rehabilitation and Productivity Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Trexler & Parrott (2018) USA Cohort N=243	**Population:** TBI=171; *Treatment Group (n=210)*: Mean Age=38.32±13.28yr; Gender: Male=142, Female=68; Mean Time Post Injury=9.61yr; *Control Group (n=34)*: Mean Age=40.30±11.54yr, Gender: Male=21, Female=12; Mean Time Post Injury=0.18yr. **Intervention:** Participants were prospectively followed to compare the effectiveness of a Resource Facilitation (RF) program to standard vocational rehabilitation. The RF program focuses on improving return to work by providing individualized treatment that helps to connect patients and caregivers with community-based resources and services, preventing barriers to return to work. Outcome measures were assessed 90d after the participants became competitively employed. **Outcome Measures:** Return to either part- or full-time competitive work or post-secondary school, Mayo-Portland Adaptability Inventory-4 (MPAI-4).	1. Of those that completed the intervention, 69% successfully returned to work, while 48% in the control group returned to work. 2. A significantly greater proportion of the treatment group obtained employment than the control group (p = .018). 3. An unknown portion of the sample reported work hours and type of employment gained. 4. Most participants worked part-time, while 36% were able to work full-time. 5. Almost half of participants returned to administrative support or laborer positions. 6. Treatment group significantly predicted employment outcome when controlling for baseline levels of disability (p = .033)
Radford et al. (2013) UK PCT $N_{initial}$=94, N_{final}=79	**Population:** TBI; Mean Age=34.3yr; Gender: Male=63, Female=16; Severity: Mild=40, Moderate=16, Severe=38. **Intervention:** Patients were assigned to vocational rehabilitation with a resource facilitator (treatment, n=34) or usual care (control; n=45). Outcomes were assessed at 3, 6, and 12 mo. **Outcome Measure:** Return to work.	1. At each time point, a greater percentage of the treatment group returned to work or school compared to the controls. 2. At 1yr, 75% of the treatment group returned to work compared to 60% of the controls. 3. 13 of 14 patients with 'minor' TBI in the treatment group returned to work by 3mo compared to 14 of 25 in the control group (p=0.03).

Discussion

Two studies have found that substantially more participants who received aid from a resource facilitator returned to work compared to standard care (Radford et al., 2013; Trexler & Parrott, 2018). Resource facilitation appears to have a positive impact on achieving vocational goals for individuals with an ABI. There is limited research focused on resource facilitation in the ABI population.

Conclusions

There is level 2 evidence (Trexler & Parrott, 2018) that connecting patients and caregivers with community-based resources and services may improve vocational outcomes in individuals post TBI.

There is level 2 evidence (Radford et al., 2013) that a resource facilitator may improve return to work compared to standard care in individuals with TBI.

KEY POINTS

- Resource facilitation may improve employment rates post TBI.

Technology Interventions

The use of health care technologies has been increasing in recent years, with a variety of tools that allow remote consultation, smart objects that can measure physiological variables and devices that facilitate rehabilitation, such as virtual reality and augmented reality (Edwards et al., 2022). Few studies currently exist which examine technological interventions for vocational rehabilitation following ABI.

TABLE 25 | Technology Interventions for Vocational Rehabilitation and Productivity Post TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Man et al. (2013) Hong Kong RCT PEDro=5 N=40	**Population:** TBI; *Artificial Intelligence Group (n=20):* Mean GCS=10.25. *Psychoeducational Group (n=20):* Mean GCS=10.05. **Intervention:** Patients were randomly assigned to 12 sessions of Artificial Intelligence Virtual Reality training (treatment) or a conventional psychoeducational program (control). Outcomes were assessed at 1, 3 and 6 mo. **Outcome Measures:** Wisconsin Card Sorting Test–computer version 4 (WCST), Tower of London Test, Vocational Cognitive Rating Scale, Employment status.	1. Participants in the treatment group performed better across all measures, but only WCST-errors (p=0.02) and WCST-conceptual level response (p<0.01) were statistically significant. 2. Both groups showed significant improvements in employment outcomes (p=0.04 and p=0.018, respectively), but there were no significant differences between groups. 3. The treatment group showed significant improvement in self-efficacy (p=0.018) However, there was no significant difference between the two groups.

Discussion

There is limited evidence on the use of technology for vocational rehabilitation for individuals who have sustained an ABI. In an RCT, Man et al. (2013) reported greater improvements in employment outcomes in participants receiving artificial intelligence virtual reality training compared to individuals receiving a conventional psychoeducational program, although this difference was not statistically significant (Man et al., 2013). It is difficult to make any definitive conclusions regarding the effect of

technology for improving vocational outcomes in ABI populations due to the limited number of studies examining this topic.

Conclusion

There is level 2 evidence (Man et al., 2013) that artificial intelligence virtual reality training may not improve employment outcomes compared to a conventional psychoeducational program in individuals post TBI.

KEY POINTS

- Virtual reality training may not be more effective than conventional psychoeducation in improving employment outcomes post TBI.

Multimodal Interventions

Individuals with moderate to severe ABI often experience multiple challenges related to psychological and physiological changes that may prevent them from returning to work; additionally, factors such as age, educational background and pre-injury occupation may impact return to work (Shames et al., 2007). Multimodal interventions have the potential to address a variety of complexities and difficulties associated with returning to work or school post ABI. These programs provide an opportunity for individuals with an ABI to receive therapy addressing multiple domains within a single program.

TABLE 26 | Multimodal Interventions for Vocational Rehabilitation and Productivity Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Twomey et al. (2021) Ireland Cohort $N_{initial}$=45 N_{final}=32	**Population:** ABI; TBI=40.6%; *T1 1yr Follow up* (n=45); Mean Age=53.34yr; Gender: Male=28, Female=17; Time Post Injury=Not Reported. *T2 7yr Follow up* (n=32); Mean age=52.7yr; Gender: Male=20, Female=12; Time Post Injury=Not Reported. **Intervention:** Longitudinal prospective cohort study to examine participants' functioning at 1yr and 7yr after accessing post-acute neurorehabilitation services. Services included: physiotherapy, occupational therapy, psychology, and speech and language therapy. **Outcome Measures:** Sociodemographic and Support Questionnaire assessing the following domains: Living independently, Physical mobility, Ability to maintain relationships, Return to work, Source of income.	1. The rates of return to work were low. While only five people living with an ABI (15.6%) returned to work at 1yr, 34.4% of participants had returned to work at 7yr follow-up. 2. At the 7yr follow-up, a state-funded disability allowance was the main source of income for almost half of the participants (43.8%). 3. 25% of participants were in receipt of wages/salary, 21.9% had a pension and the remaining 9.4% of the participants described their income as being drawn from 'other' sources or a combination of sources. 4. Return to work at 7yr was not associated with age, gender, mobility, years of

Author Year Country Study Design Sample Size	Methods	Outcome
		education, or the type of ABI experienced (all p > .01)
Shany-Ur et al., (2020) Israel PCT $N_{initial}$=143, N_{final}=141	**Population:** TBI=84, Not TBI=57; *Comprehensive-Holistic Neuropsychological Rehabilitation Group* (n=33); Mean Age=30.7yr; Gender: Male=24, Female=9; Time Post Injury=3.2yr; *Vocational-Focused Neuropsychological Rehabilitation* (n=55); Mean Age=35.4yr; Gender: Male=42, Female=13; Time Post Injury=3.8yr. *Individual Neuropsychological Rehabilitation* (n=55); Mean Age=33.4yr; Gender: Male=38, Female=17; Time Post Injury=4.5 yr. **Intervention:** Individuals participated in one of three community-based neuropsychological rehabilitation programs: a Comprehensive-Holistic Neuropsychological Rehabilitation program for 5–7 hr/4d/wk for 10mo; a Vocational-Focused Neuropsychological Rehabilitation program for 4-18mo; and an Individual Neuropsychological Rehabilitation program for 1–4 hr/wk. **Outcome Measures:** Employment Status and Vocational Stability; Community Integration Questionnaire (CIQ); Wimbledon Self-Report Scale (WSRS); Perceived Quality of Life Questionnaire (PQOL)	1. Work stability improved significantly across time, regardless of program type (p < .001) and it was corroborated by a significant linear effect for time across groups (p < .001). 2. Community integration overall score (reflecting social, vocational, and domestic functioning) improved significantly across time, regardless of program type (p < .001) with a significant linear effect for testing time, across groups (p < .001).
Perumparaichallai et al. (2020) USA Pre-Post N=107	**Population**: TBI=62, CVA=27, Other (Anoxia, Tumor, & infection) =14; Mean Age=35.81yr; Gender: Male=62, Female=45; Mean Time Post Injury=3.02yr; Severity: Mild=3, Moderate-to-Severe=36, Severe=18, Unknown=3 **Intervention:** Participants attended holistic milieu-oriented neurorehabilitation between 1986 and 2016. Participant completed one or more of the intervention programs that aimed to facilitate home and community independence, social relationships and quality of life, as well as work and/or school re-entry. The intervention programs incorporated individual and group therapies (intervention length=3-5d/wk, 4-6h/d). Primary outcome measures were assessed at program admission, discharge, and follow-up in 2016. Secondary outcome measures were assessed at follow-up in 2016. **Outcome Measures**: Productivity status (e.g., return-to-work/school), Driving status, Mayo-Portland Adaptability Inventory-4 (MPAI-4) and a long-term outcome questionnaire (LOQ) specifically developed for this study.	1. Eighty-nine percent of the participants were productive at up to 30yr post-discharge (73% engaged in competitive work and/or school) after excluding the retired participants. 2. At the follow-up in 2016, 70% of participants were had an annual income of $20,000 or more.
Rumrill Jr et al. (2019)	**Population:** TBI=146; Mean Age=26yr; Male=80, Female=66; Mean Time Post Injury=Not reported	1. The CMI Curiosity subscale score decreased significantly from baseline to 6mo follow up

Author Year Country Study Design Sample Size	Methods	Outcome
USA Pre-Post $N_{Initial}$=146, N_{Final}=125	Severity: Mild=24%, Moderate=27.2%, Severe=47.9%, Unknown=6.8% **Intervention**: Participants took part in Project Career, an individualized support program, over the course of 5yr. The program merged Cognitive Support Technology (CST) and Vocational Rehabilitation practices and was designed to improve the career readiness and employment outcomes of undergraduate students with TBI. Project Career students who graduated from their degree programs during the five-year program received post-graduation follow-up services for 1yr. Outcome measures were assessed at baseline and at 6mo intervals for the duration of the program. **Outcome Measures**: Career Maturity Inventory—Form C (CMI), a scale measuring acceptance of disability, perception and usage of technology rated on a reverse-scored scale from 5 to 15 with lower scores indicating more positive experiences, ratings of interpersonal/emotional, cognitive, and daily activity proficiencies, academic performance (measured by GPA), engagement in career preparatory activities, employment status.	(p=.032), indicating more concrete and definitive career plans. 2. Participants' mean GPA increased from 2.87 at baseline to 3.02 at 12mo follow-up. 3. The majority of the participants engaged in one or more career preparatory activities during their participation in the program. 4. Of the participants who were currently pursuing their degrees, 71% reported being employed full or part-time as of the writing of the article, which was higher than the baseline employment rate (44.4%). 5. Of those who have graduated from their degree programs as of the writing of the article, 80.5% were employed full or part-time.
Cogne et al. (2017) USA Cohort N=57	**Population:** TBI=39, Other=18; Mean Age=34.7yr; Gender: Male=38, Female=19; Mean Time Post Injury=9-247mo. **Intervention:** Patients were recruited from those who completed the 2008 French evaluation, retraining, social and vocational unit (UEROS) program for 5yr follow-up to assess family and vocational status, autonomy, and life satisfaction. **Outcome Measures:** Health, return to work, life satisfaction, activities of daily living, psychosocial and community integration.	1. Participants were 33% more independent when completing activities of daily living than at inclusion. 2. At 5yr follow-up, 47% were working compared with 11% when the cohort first entered the program.
Foy (2014) UK Cohort N=97	**Population:** ABI=119; Age Range: 16-36yr; Gender: Male=73, Female=24; Time Post Injury: >1yr; Severity: Severe-to-Very-Severe=119. **Intervention**: Retrospective cohort of participants who attended QEF Neuro Rehabilitation Services (QEF Neuro Rehab), a program that provides residential intensive neurorehabilitation, education, and vocational rehabilitation for young adults with ABI. Participants received interventions for up to 5h/d tailored to their needs. Outcome measures were	1. Over half (53 %) of the clients attained a positive vocational outcome.

Author Year Country Study Design Sample Size	Methods	Outcome
	assessed at least 1-yr after the completion of the program via postal questionnaire or telephone. **Outcome Measures**: Vocational outcome (employment status or return to school).	
Bonneterre et al. (2013) France Pre-Post N=100	**Population:** TBI; Gender: Male=80, Female=20. **Intervention:** Patients attended a personalized service of accompaniment and follow-up to employment (SPASE) program. Two interviews were conducted: one over the phone and one with a vocational rehabilitation specialist from the SPASE workplace reintegration programme. **Outcome Measures:** Return to work.	1. Compared to pre-intervention, significantly more individuals were at work after treatment (p=0.001). 2. Workplace support was a highly significant factor in returning to work in the short term (<3yr; p<0.001) and in the medium term (>3yr; p=0.01). 3. Regularity of assistance (p=0.05) and physical disabilities (p=0.05) both affected workplace reintegration in the short term.
Watanabe (2013) Japan Pre-Post N=300	**Population:** TBI; Mean Age=36.7yr; Gender: Male=247, Female=53; Severity: Moderate=48, Severe=247, Unavailable=5. **Intervention:** Patients attended an inpatient rehabilitation program with supported employment. Participants were grouped based on their Barthel Index (BI) score. **Outcome Measures:** Employment status, Activities of Daily Living (ADL).	1. Group A (BI score <20) and Group B (20<BI score<80) displayed significant gains in ADL (p>0.05), but Group A was not fully independent in ADL. 2. No members of Group A returned to work, but 35.7% of Group C (BI score of >80) and 10.7% of Group B did return to work.
Geurtsen et al. (2012) Netherlands Post-Test $N_{Initial}$=67, N_{Final}=63 *Follow-up study of Geurtsen et al. (2011)	**Population:** TBI=42, Mean Age= 24.7±7.2yr, Gender: Male=42, Female=21, Mean Time Post Injury=5.1±5.3yr, Severity: Mean GCS=7.8 **Intervention:** Participants attended a structured residential treatment program consisting of three modules: the independent living module (100h per person), the social-emotional module (110h per person), and the vocational module (44h per person). Outcome measures were assessed 1 and 3yr post treatment. **Outcome Measures:** Community Integration Questionnaire (CIQ), Employability Rating Scale (ERS), living situation, school, work situation, work hours, Center for Epidemiological Studies Depression Scale (CES-D), World Health Organization Quality of Life Scale Abbreviated (WHOQOL-BREF; 5 scales)	1. There were no significant differences for any of the outcome measures between the 1yr and 3yr follow-up assessments (p>.05).
Geurtsen et al. (2011) Netherlands Pre-Post	**Population:** TBI=47, stroke=7, brain tumor=10, encephalitis=4, hypoxia=2; Mean Age: 25.1±7.9yr; Gender: Male=46, Female=24; Mean Time Post Injury=5.2y; Severity: Mean GCS=7.5	1. Participants showed significant improvement in employability immediately after treatment (ERS; p<.001).

Author Year Country Study Design Sample Size	Methods	Outcome
$NI_{initial}$=70, N_{Final}=67	**Intervention:** Participants attended a structured residential treatment program consisting of three modules: the independent living, the social-emotional module, and the vocational module. Outcome measures were assessed at inclusion (T0), 3mo later (T1), end of the treatment (T2) and 1yr follow-up after the end of treatment (T3). **Outcome Measures**: Community Integration Questionnaire (CIQ), Employability Rating Scale (ERS), living situation, school, work situation, work hours, Center for Epidemiological Studies Depression Scale (CES-D), EuroQOL quality of life scale (EQ-5D), World Health Organization Quality of Life Scale Abbreviated (WHOQOL-BREF; 5 scales), Global Assessment of Functioning (GAF) scale	2. No significant change in work hours was observed immediately after treatment (p>.05). 3. At follow-up, 57.3% of the patients were working, compared to 17.9% before treatment.
Geurtsen et al. (2008) Netherlands Pre-Post N=24	**Population:** TBI=18, Stroke=3, Other=3; Mean Age=28.5yr; Gender: Male=18, Female=6; Mean Time Post Injury=5.4yr; Mean GCS=5.9. **Intervention:** Patients attended the Brain Integration Program with 3 modules: independent living, work, and social-emotional. Outcomes were assessed before and after treatment, with follow-up at 1yr and 3 yr. **Outcome Measures:** Community Integration Questionnaire (CIQ), Centre for Epidemiological Studies-Depression (CES-D), Quality of Life, Employability Rating Scale (ERS), Employment status.	1. The increase in employability was only significant between discharge and 1yr (p=0.03). 2. Patients working increased from 38% to 58% from pre- to post-intervention, with mean hours worked per week increasing from 8 to 15.5. 3. There were no significant improvements from 1-3yr for community integration (CIQ), employability (ERS), work hours (ERS), emotional well-being (CES-D), or QoL. 4. From 1-3yr, the number of patients working slightly increased (33 vs. 41) but the number of patients living independently decreased (42 vs. 37).
Walker et al. (2006) USA Cohort N=1341	**Population:** TBI; Mean Age=35yr; Gender: Male=1033, Female=308; Mean GCS=8. **Intervention:** Individuals participated in an individualized comprehensive inpatient rehabilitation program. **Outcome Measures:** Category of Productive Activity, Census Occupational Category, Occupation Group, Functional Independence Measure, Duration of Unconsciousness.	1. Overall, 39% returned to competitive employment in any occupation 1yr post injury, 9% were students/retired/or homemakers, and roughly half were unemployed. 2. Participants in professional/managerial jobs pre-injury showed 56% return to work compared to those in skilled trades (40%) and manual labor (32%). 3. Those scoring at the 75% level on the FIM were 3.33 times more likely to return to work than those at the 25% level.

Author Year Country Study Design Sample Size	Methods	Outcome
O'Neill et al. (2004) USA Case Control N=42	**Population:** TBI; Gender: Male=34, Female=8. **Intervention:** Patients who attended the Program Without Walls (PWW; n=21) were compared to those receiving traditional vocational rehabilitation services (n=21). **Outcome Measures:** Case status at closure, weekly earnings at closure, hours working at closure, cost of case services.	1. More cases in the PWW group were successfully closed (57% vs. 24%; p=0.03), had higher mean earnings ($328.70 vs. $124.00; p=0.03), and worked more hours on average (32.08 vs. 17.8; p=0.04) compared to controls. 2. The average cost of case services per PWW consumer was $3586.10 vs. $3326.00 for non-PWW consumers, although this difference was not statistically significant (p=0.43).
De Kort et al. (2002) Netherlands Post-Test $N_{Initial}$=25, N_{Final}=20	**Population:** ABI; Mean Age=29yr; Mean length of coma=4.7wk. **Intervention:** Patients attended the Come Back Program (CBP) aimed at regaining maximal independence in work and leisure activities. Participants received aid from social workers, a neuropsychologist, and a physician. Outcomes were assessed by chart review and at a mean of 3yr after the program. **Outcome Measures:** Employment status, Living situation.	1. Fourteen patients had a job pre-injury, and 4 patients within 3mo before CBP. 2. For those with a pre-injury job, 10 of 14 achieved employment after CBP, but only 7 were paid and only 3 did the same work as pre-injury. 3. The two main goals expressed by patients were solving problems in living and work-related problems, 9 of 11 were satisfied with their result of the first goal, and 12 of 15 were satisfied with the second goal.
Malec & Degiorgio (2002) USA Cohort N=114	**Population:** TBI=73, ABI=41; Mean Age=37.4yr; Gender: Male=70, Female=44; Mean Time Post Injury=65.5mo. **Intervention:** Patients in 3 different rehabilitation pathways were compared at 1yr: (1) Specialized vocational services (SVS); (2) SVS and community reintegration (1 hr/day, 3 days/wk); and (3) SVS and comprehensive day treatment (6 hr/day, 5 days/wk). **Outcome Measures:** Mayo-Portland Adaptability Inventory-4 (MPAI-4), Vocational-Independence Scale (VIS), Community-Based Employment (CBE).	1. VIS outcomes differed significantly between groups at placement (p=0.01) but not at 1yr (p=0.06). 2. CBE success rates for group 1, 2, and 3 were 77%, 85%, and 84%, respectively (p>0.10). 3. The number of individuals returning to work for a pre-injury employer did not differ significantly between groups. 4. In group 3, MPAI-4 scores did not significantly differ between those who were successful and those who were not.
Malec (2001) USA Pre-Post $N_{Initial}$=113, N_{Final}=96	**Population:** ABI=113, *Program Graduates (n=96)*: TBI=72%, CVA=19%, Other (e.g., anoxia) =9%; Mean Age=34.2±12.2yr; Gender: Male=73%, Female=27%; Mean Time Post Injury=4.6±6.6yr; Severity: Mild=7%, Moderate=7%, Severe=82%, Undetermined=4%, *Dropouts (n=17):* TBI=71%, CVA=6%, Other (e.g., anoxia) =23%; Mean Age=29.4±12.4yr; Gender: Male=71%, Female=29%; Mean Time Post Injury=1.3±1.5yr; Severity: Mild=8%, Severe=92% **Intervention:** Participants attended a comprehensive day treatment (CTD) program involving daily group sessions and individual therapy as needed, for an	1. At 1yr follow-up, 39% of program graduates were working independently, 10% were in transitional placements, and 18% were in supported or volunteer work.

Author Year Country Study Design Sample Size	Methods	Outcome
	average of 189.5d. The CTD program utilized a transdisciplinary approach, supportive feedback, and a variety of therapeutic modalities (peer, staff, videotape). Outcome measures were assessed before and after the program, and at 1yr follow-up **Outcome Measures:** Independent living status, vocational independence scale, Mayo-Portland Adaptability Inventory (MPAI-22), Goal Attainment Scaling (GAS)	
Malec et al. (1995) USA Post-Test $N_{Initial}$=67, N_{Final}=51	**Population:** TBI=67; Age Range=18-55yr; Gender: Not reported; Mean Time Post Injury=Not Reported; Severity: Severe=67 **Intervention:** Participants received integrative medical center- and community-based services that targeted barriers to employment identified by the research team. The medical and vocational services were integrated through the collaboration between a nurse case coordinator (NCC) and a vocational case coordinator (VCC) within the medical centre. Vocational services were individualized for each participant based on his/her medical history, needs, and goals. The intervention program was still ongoing as of the writing of the article. Outcome measures were assessed 1yr after the implementation of the intervention program. **Outcome Measures**: Mayo-Portland Adaptability Inventory, a vocational rating scale that uses a 5-point rating system to identify the level of vocational functioning, additional measures of vocational success (level of independent living, job type and setting, rate of pay, types and costs of vocational supports being used).	1. Following the first year of the implementation of the program, 34% of the participants were able to participate in full- or part-time community-based work or training programs.
Haffey & Abrams (1991) USA Cohort $N_{Initial}$=241, N_{Final}=199	**Population:** TBI=241, *WRP Group (n=130)*: Mean Age=32yr, Gender: Male=72%, Female=28%, Time Post Injury=Not reported; Severity: Moderate-to-Severe=130*, Day Treatment Group (n=35)*: Mean Age=31yr; Gender: Male=81%, Female=19%; Time Post Injury=Not reported; Severity: Moderate-to-Severe=35*, Comparison Group (n=76)*: Mean Age=33yr; Gender: Male=65%, Female=35%; Mean Time Post Injury=not reported; Severity: Moderate-to-Severe=76 **Intervention**: Participants were clients who received one of the following interventions: (1) The Work Re-Entry Program (WRP; with approx. 60h of staff assistance) that had components such as vocational	1. For the WRP group, there was a 68% placement rate in paid employment, a 71% employment retention rate, and a 75% employment stability rate. 2. Engagement in paid employment was less than 40% for a group of graduates of the Day Treatment Group and the Comparison Group who only received inpatient rehabilitation.

Author Year Country Study Design Sample Size	Methods	Outcome
	assessment, job development, transitional employment program, and job placement. (2) A Day Treatment Program where return-to-work was not one of the treatment goals, or (3) No formal post acute rehabilitation services following discharge from in-patient rehabilitation (control group). Outcome measures were assessed every 6mo. **Outcome Measures:** Employment status, hours worked, wages, functional performance on the job, activity patterns, Preliminary Diagnostic Questionnaire (PDQ), a self-assessment questionnaire measuring perceived interpersonal and community survival skill competency, emotional status, and life satisfaction, a family/caregiver assessment, and a personality profile	

Discussion

Comprehensive Day Treatment programs utilizing diverse therapeutic techniques and multidisciplinary teams may potentially improve vocational outcomes in individuals with ABI. This is illustrated in a pre-post study by Malec (2001), in which more than half of the program graduates were able to obtain competitive employment, transitional placements, or volunteer work one year after completing an intervention that used a transdisciplinary approach. In a cohort study, Malec and Degiorgio (2002) compared and combined three different rehabilitation approaches. Vocational services were provided either alone, with community reintegration, or with comprehensive day treatment. Employment rates were 77% or higher in each group, but none of the treatments were found to be more effective than the others (Malec & Degiorgio, 2002).

Several multimodal rehabilitation programs for individuals with ABI reported favourable improvements in vocational outcomes following program completion. The service of accompaniment and follow-up to employment (SPASE) program, the French evaluation, retraining, social and vocational unit (UEROS) program, Mayo Clinic Comprehensive Day Treatment Program, Brain Integration Program, Come Back Program, Program Without Walls, QEF Neuro Rehabilitation Services, Work Re-entry Program, and Project Career all resulted in vocational-related improvements (Bonneterre et al., 2013; Cogné et al., 2017; De Kort et al., 2002; Foy, 2014; Geurtsen et al., 2008; Geurtsen et al., 2011; Haffey & Abrams, 1991; O'Neill et al., 2004; Rumrill Jr et al., 2019). Integrative medical center- and community-based services targeting barriers to employment was also shown to have a positive impact on employment outcomes in individuals with ABI (Malec et al., 1995). However, it should be noted that conclusions

cannot be made regarding which of those programs is most effective, as no studies have compared one to another.

Unlike other multimodal rehabilitation programs mentioned above, Project Career was specifically geared towards veteran and civilian undergraduate students with TBI instead of adults with ABI in general (Rumrill Jr et al., 2019). Besides improving career readiness and employment outcomes in participants, the program significantly enhanced program participants' academic performance, independence, and psychosocial well-being (Rumrill Jr et al., 2019). In addition to improved vocational outcomes, the UEROS and Come Back Program improved independence (Cogné et al., 2017; De Kort et al., 2002). The Brain Integration Program also reported increased independence, improved employability, and less depressive symptoms immediately after treatment, as well at one- and three-years post discharge (Geurtsen et al., 2012; Geurtsen et al., 2008; Geurtsen et al., 2011). Though it has been thought that increased independence and societal awareness post ABI may lead to increased emotional burden, a decrease in depressive symptoms along with an increase in independence suggest otherwise.

General inpatient or outpatient rehabilitation programs may also be effective for improving employment outcomes. In a pre-post study by Perumparaichallai et al. (2020), 89% of participants reported engaging in competitive employment, structured volunteer work, or education at up to 30 years after receiving milieu-oriented neurorehabilitation with programs in inpatient and community settings. Similarly, in a PCT study, Shany-Ur et al. (2020) examined three community-based programs, a comprehensive-holistic neuropsychological rehabilitation program, a vocational-focused neuropsychological rehabilitation, and an individual neuropsychological rehabilitation program. The authors found that work stability improved across time, regardless of the program with improvements reflecting social, vocational and domestic functioning (Shany-Ur et al., 2020). In a cohort study, Walker et al. (2006) found that 39% of individuals were employed at 1-year post injury following inpatient rehabilitation. However, low rates of return to work were reported in a cohort study by Twomey et al. (2021) that assessed individuals 1 year and 7 years after participating in post-acute interdisciplinary neurorehabilitation services.

Some factors that increase whether an individual has a successful return to work trajectory include independence, workplace support, and higher Functional Independence Measure and Barthel Index scores (Bonneterre et al., 2013; Walker et al., 2006; Watanabe, 2013). Walker et al. (2006) also found that type of occupation may influence employment outcomes; participants who worked in professional or management roles were more likely to return to work compared to skilled trade or manual workers.

Conclusions

There is level 2 evidence (Cogne et al., 2017) that the Evaluation, Retraining, Social, and Vocational Unit (UEROS) program may improve return to work outcomes in individuals post ABI.

There is level 2 evidence (Watanabe, 2013; Walker et al., 2006) that inpatient rehabilitation may improve return to work in individuals post TBI. However, the benefits of post-acute neurorehabilitation services may not be maintained at 7 years (Twomey et al., 2021).

There is level 2 evidence (Shany-Ur et al., 2020) that a comprehensive-holistic neuropsychological program, a vocational-focused and an individual neuropsychological may improve work stability post ABI across time.

There is level 2 evidence (Malec & Degiorgio, 2002) that specialized vocational services alone may not be less effective than specialized vocational services paired with either community reintegration or comprehensive day treatment for facilitating return to work in individuals post ABI.

There is level 2 evidence (Haffey et al., 1991) that a work re-entry program may improve return to work outcomes in individuals with moderate to severe TBI.

There is level 3 evidence (O'Neill et al., 2004) that the Program Without Walls may improve employment rates and incomes compared to traditional vocational rehabilitation in individuals post ABI with no associated increase in the cost of case management services.

There is level 4 evidence (Perumparaichallai et al., 2020) that a holistic milieu-oriented neurorehabilitation intervention may improve productivity in individuals with ABI.

There is level 4 evidence (Rumrill et al., 2019) that an individualized support program involving cognitive support technology and vocational rehabilitation interventions may increase job readiness and career prospects in undergraduate students with TBI.

There is level 4 evidence (De Kort et al., 2002) that the Come Back Program may improve independent living and return to work post ABI.

There is level 4 evidence (Geurtsen et al., 2008; Geurtsen et al., 2011; Geurtsen et al., 2012) that a structured residential community reintegration program may improve and employability post ABI.

There is level 4 evidence (Bonneterre et al., 2013) that the personalized service of accompaniment and follow-up to employment (SPASE) program may improve workplace reintegration post TBI.

There is level 4 evidence from one case series (Foy, 2014) an integrated intensive residential neurological and vocational rehabilitation program may improve vocational outcomes in individuals post severe ABI.

There is level 4 evidence (Malec, 2001) that a comprehensive day treatment program incorporating daily group sessions and a transdisciplinary approach may improve vocational outcomes in individuals post ABI.

There is level 4 evidence (Malec et al., 1995) that integrative medical center- and community-based services specifically targeting barriers to employment may improve vocational outcomes in individuals with severe TBI.

KEY POINTS

- Various multimodal interventions may improve return to work and school post ABI.
- While multimodal programs are heterogenous and present different approaches, interventions that address independence, social awareness and neuropsychological rehabilitation may result in greater vocational improvements.

Return to Driving

Driving is considered 'occupation enabler', allowing individuals to participate in activities of daliy living, and to fulfill roles within their communities (Classen et al., 2009). Losing the ability to drive is challenging for individuals with ABI, since driving is often associated to social engagement and general independence (Lane & Benoit, 2011). Given that driving requires the integration of motor skills, visualk stimuli, information processing and judgement and decision-making, returning to pre-injury driving can be difficult for individuals who have sustained a brain injury (Classen et al., 2009). Appropriate recovery of motor and cognitive abilities post brain injury is critical to be able to return to driving, particularly skills related to attention, reaction time and information processing speed; additionally, a driving assessment may be needed to determine if the individual is fit to drive (Palubiski & Crizzle, 2016). Individuals with an ABI often return to driving in an effort to feel independent, even if they are not fit to do so (Leon-Carrion et al., 2005). This can be concerning given that individuals who have sustained moderate to severe injuries often continue to present with cognitive and behavior impairments several years post injury, resulting in risks associated with road safety (Imhoff et al., 2016). Return to driving aftrer an ABI is a complex process that involves multiple challenges for individual; for instance, driving requires the use of multiple cognitive abilities in coordination in a

dynamic environment, and those who have sustained a brain injury may not be fulkly aware of any potential impairments that can impact their driving abiltiy, and they might not seek a formal professional driving evaluation (Perna et al., 2021).

TABLE 27 | Interventions for Return to Driving Post ABI

Author Year Country Study Design Sample Size	Methods	Outcome
De Tanti et al. (2020) Italy Case Series N=217	**Population:** Severe ABI; TBI=112; Vascular=101; Anoxia=9; Infective=4; *Suitable for Driving* (n=172); Mean Age =42.43yr; Gender: Male=145, Female=27; *Unsuitable for Driving* (n=45); Mean Age=44.53yr; Gender: Male=38, Female=7; Mean Time Post-Injury=Not Reported. **Intervention:** Retrospective analysis of demographic, clinical variables and motor disability in individuals judged 'suitable' or 'unsuitable' for safe return to driving. **Outcome Measures:** Griffith Scale, Prescribed vehicle assistive devices, Failure to obtain license, or renewal of driver's license.	1. In terms of vehicle adaptations, the most frequent was automatic transmission, where 81 of 88 candidates (92%) required this assistive device. 2. Of the 172 candidates declared "suitable" for a return to driving, 90 with and 82 without vehicle assistive devices to compensate for residual motor disability. 3. Neither variables such as sex and age, or the distinction between traumatic and non-traumatic etiology proved to be indicators predictive of outcome with respect to the procedure aimed at renewal of driving licenses after severe ABI.
Perumparaichallai et al. (2020) USA Pre-Post N=107	**Population**: TBI=62, CVA=27, Other (Anoxia, Tumor, & Infection) =14; Mean Age=35.81yr; Gender: Male=62, Female=45; Mean Time Post Injury=3.02yr; Severity: Mild=3, Moderate-to-Severe=36, Severe=18, Unknown=3 **Intervention:** Participants attended holistic milieu-oriented neurorehabilitation and completed one or more of the intervention programs that aimed to facilitate: Home and community independence, social relationships and quality of life, work and/or school re-entry. The intervention length was 3-5d/wk, 4-6h/d. Primary outcome measures were assessed at program admission, discharge, and follow-up in 2016. Secondary outcome measures were assessed at follow-up in 2016. **Outcome Measures**: Productivity status (e.g., return-to-work/school), driving status. Mayo-Portland Adaptability Inventory-4 (MPAI-4) and a long-term outcome questionnaire (LOQ) specifically developed for this study.	1. Only 14% out of 102 study participants were driving at the time of program admission, whereas 58% out of 96 were driving at the time of discharge. Seventy percent of 107 participants were driving at the time of follow-up. 2. Older age at the time of injury (p=.03), shorter duration between injury and treatment (p=.007), and better functionality indicated by lower MPAI-4 Ability Index scores (p=.01) significantly predicted a return to driving status at the time of study participation.
Ross et al., (2018) Australia Cohort N=340	**Population:** TBI=340; *Passed Initial Driver Assessment/No Lessons Group (n=246):* Mean Age= 38.65 ± 15.52yrs; Gender: Male=204, Female=60; Mean Time Post Injury= 7.62 ± 7.79mo; Severity: Mean GCS= 9.55 ± 4.37. *Failed Initial Driver Assessment/Driving Lessons Group (n=94):* Mean Age= 39.50 ± 18.88yr; Gender: Male=63, Female=31; Mean Time Post Injury= 8.21 ± 8.62mo; Severity: GCS= 7.69 ± 4.36	1. Of the 340 participants, 246 passed the initial driver assessment. 2. A significant difference was found in injury severity between those who passed the initial driver assessment and those who required on-road training, with those requiring on-road training having lower GCS scores (p<.001) and longer PTA duration (p<.001).

Author Year Country Study Design Sample Size	Methods	Outcome
	Intervention: Participants first completed an off-road assessment conducted by an occupational therapy (OT) driver assessor and a standard on-road assessment in a dual-controlled automatic vehicle accompanied by a driving instructor and an OT driver assessor (50 to 60min in duration). Those who failed the initial driver assessment completed on-road training lessons addressing individual goals, which were developed by an OT driver assessor, based on issues identified during the off- and on-road assessments (average number of lessons=7, average driving instructor hours=14) **Outcome Measures:** Goals of on-road training lessons, on-road driving reassessments license restrictions	3. Of those who failed the initial driver assessment, 93% resumed driving following on-road training; 45% with an open license, 48% with a restricted license. 4. Lesson goals were recommended to develop compensatory strategies for cognitive impairments (64%), improve previously learned driving skills (57%), improve confidence (53%), and address physical (26%) or visual impairment (16%).
Perumparaichallai et al. (2014) USA Case Series N=128	**Population:** TBI=75, Stroke=36, non-TBI=17; Mean Age=34.7yr; Gender: Male=76, Female=52; Mean Time Post Injury=10.42mo. **Intervention:** Patients attended a milieu-oriented neurorehabilitation program consisting of clinic-based therapies (6hr/d, 4d/wk). Neuropsychological evaluations were done before and after treatment to assess fitness to drive. **Outcome Measures:** Return to driving, Trail Making Test A and B (TMT-A/B), Wechsler Adult Intelligence Scale (WAIS-III): Arithmetic (ART), Letter Numbering Sequencing (LNS), Symbol Search, Digit Symbol Coding, Block Design, Matrix Reasoning (MR).	1. Following a neurorehabilitation program, 54% of participants returned to driving. 2. There was a significant difference between the driving and non-driving groups on LNS ($p<0.004$), Digit span coding ($p<0.0001$), Symbol Search ($p<0.0001$), Block Design ($p<0.001$), TMT-A ($p<0.0001$), and TMT-B ($p<0.001$) after treatment. 3. There was no significant difference between groups on MR ($p=0.01$) or ART ($p=0.15$) after treatment.
Leon-Carrion et al. (2005) Spain Pre-Post N=17	**Population:** TBI; Mean Age=22.94yr; Mean GCS=6; Mean Time Post Injury= 10.94mo. **Intervention:** Patients attended a neurorehabilitation program. Patients were assessed based on return to driving at the start of rehabilitation despite recommendations otherwise. **Outcome Measures:** Functional Independence Measure + Functional Assessment Measure-Revised Scale (FIM+FAM-R).	1. Those who returned to driving had significantly higher mean total FIM+FAM scores at admission ($p=0.000$) and discharge ($p=0.001$) compared to non-drivers. 2. At discharge, FIM+FAM-R for all participants raised to 80% from 42.5%. 3. At admission, 35.3% were driving despite not being fit to do so; 70.6% were driving at discharge.
Kewman et al. (1985) USA PCT N=35	**Population**: Severe ABI=24; *Experimental Group (n=13), ABI Control Group (n=11):* Mean Age=24.2yr; Gender: Not reported; Mean Time Post Injury=3.7yr; Severity: Severe=24; *Normative Control Group (n=11*): ABI=0; Mean Age=Not reported; Gender: Not reported; Mean Time Post Injury=Not Reported; Severity: Not Reported. **Intervention**: The Experimental Group received the psychomotor training program with the AMIGO (brand name) vehicle. Training consisted of eight 2hr driving sessions where participants were trained on seven driving-related exercises. The ABI Control Group spent time operating the AMIGO but did not receive training on the specific tasks. The Normative Control Group were trained on some of the tasks with the AMIGO	1. Compared to the ABI Control Group, the Experimental Group showed significantly greater improvement in performance on tests of on-the-road automobile driving, in all but one aspect, including percentage of correct tracking ($p<.001$), percentage of correct signs ($p<.05$), composite score ($p<.01$), and driver educator ratings ($p<.02$). 2. The Experimental Group demonstrated significant improvement in time needed to complete the tasks and accuracy of completion for all training exercises except the S-curve and straightaway ($p<.05$).

Author Year Country Study Design Sample Size	Methods	Outcome
	vehicle. Outcome measures were assessed before and at the conclusion of the training program. **Outcome Measures**: Driver educator ratings and objective scores of on-the-road driving test performance (lane tracking, accuracy of turns, ability to notice and identify specified road signs, and the number of major safety errors committed over the course of the test), performance on tasks for training exercises.	

Discussion

Participation in a multidisciplinary neurorehabilitation program was found to improve driving as well as driving-related impairments, increasing the rate of individuals returning to driving following ABI (Leon-Carrion et al., 2005; Perumparaichallai et al., 2014; Perumparaichallai et al., 2020). After participating in these programs, 54-71% of individuals returned to driving (Leon-Carrion et al., 2005; Perumparaichallai et al., 2014; Perumparaichallai et al., 2020), though one study found that 30% were driving upon admission to rehabilitation despite not being fit to do so (Leon-Carrion et al., 2005). In a retrospective study by De Tanti et al. (2020), from the 172 candidates declared “suitable” for a return to driving, 90 used vehicle assistive devices to compensate for residual motor disability.

Functional status, as well as performance on tests of visual attention, working memory, processing speed, and task switching were correlated with return to driving (Perumparaichallai et al., 2014; Perumparaichallai et al., 2020). Specifically, those who resumed driving achieved better scores on the Functional Independence and Assessment Measures than those who did not resume (Leon-Carrion et al., 2005; Perumparaichallai et al., 2020). Simulation training of psychomotor skills may improve return-to-driving outcomes in individuals with ABI. Specifically, in a study conducted by Kewman et al. (1985), those who completed training exercises targeting psychomotor skills in a wheelchair showed significantly greater improvement in on-road driving performance, compared to control group participants who did not receive the intervention. Another study found that on-road training lessons addressing individual goals identified by an occupational therapist driver assessor facilitated return-to-driving in participants with ABI as well (Ross et al., 2018).

Conclusions

There is level 2 evidence (Kewman et al., 1985) that simulation training of psychomotor skills may improve the ability to drive in individuals with severe ABI.

There is level 2 evidence (Ross et al., 2018) that on-road training lessons addressing individual goals may improve return to driving in individuals with ABI who failed an initial on-road driving test.

There is level 4 evidence (Perumparaichallai et al., 2014; Leon-Carrion et al., 2005) that multidisciplinary neurorehabilitation may improve return to driving in individuals post ABI.

There is level 4 evidence (Perumparaichallai et al., 2020) that holistic milieu-oriented neurorehabilitation interventions may improve return to driving in individuals with ABI.

There is level 4 evidence (De Tanti et al., 2020) that individuals with ABI may require vehicle assistive devices to safely return to driving.

KEY POINTS

- Multidisciplinary neurorehabilitation and on-road training lessons may help individuals to return to driving post moderate to severe ABI.
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Caregiving and Caregiver Burden

Following an ABI, someone often takes on the responsibility of ensuring that the injured individual receives proper care, either a family member, a professional paid caregiver, or a larger network of individuals. Family caregiving is influenced by socioeconomic factors such as age, race and income, as well as other factors unique for each family, such as skill competence, patterns of living and the relationship they have with the individual who sustained the injury (Degeneffe, 2001). ABI can have a negative impact on families, often resulting in prolonged exposure to stress and strain, loss of identity, changes in roles, and harmful effects on social, emotional, structural and financial functioning of the family unit (Karpa et al., 2020). Providing support for individuals with ABI can be time-consuming, physically and emotionally demanding for families, often leading to caregiver burden, which has been associated with psychological, social, economic, physical and emotional problems, long-term stress, low quality of life, low life satisfaction and burnout (Kjeldgaard et al., 2023). Caregivers of individuals who have sustained a brain injury may experience loss of social connections (Hanks et al., 2007)., and require extended support, including social and financial support, assistance with life planning and counseling, among other services (Sodders et al., 2020).

The responsibility of providing care for individuals with ABI can lead to increased levels of stress. Caregiver individual characteristics, such as coping strategies, can also influence the level of stress experienced by these individuals (Chronister et al., 2016; Davis et al., 2009; Katz et al., 2005). Caregiving

can increase the risk of depression, which may be greater in ABI caregivers compared to non-ABI caregivers (Warren et al., 2016). Further, caregiver depression is significantly correlated with burden, life satisfaction, and coping strategies (Gulin et al., 2014). Fortunately, caregiver burden may decrease over time (Bayen et al., 2016; Dillahunt-Aspillaga et al., 2013), as the family member with an ABI shows improvement and the caregiver becomes accustomed to providing care. The caregiver experience can be broken down into three categories: burden, satisfaction, and mastery (Albert et al., 2002). Common indicators of each of these categories can be found in the following table:

TABLE 28 | Common Indicators of Caregiver Burden, Satisfaction, and Mastery (Albert et al., 2002).

Caregiver Burden	Caregiver Satisfaction	Caregiver Mastery
• Not enough time. • Anxiety. • Not enough sleep. • Not enough privacy. • Strain on personal relationships. • Depression. • Interruptions at work. • Low energy. • Inability to get outside the home. • Use of alcohol or drugs. • Feeling overwhelmed. • Isolation. • Uncomfortable having visitors.	• Patients appreciate caregiver. • Caregivers feel close to patient. • Caregivers enjoy helping patient. • Caregiving adds meaning to life. • Caregiver gets needed support.	• Feeling that one is a good care manager. • Feeling that one understands patient problems. • Knowing where to go for help. • Confidence handling caregiving challenges. • Having a reasonable plan for the future. • Effective handling of benefits and insurance.

Caregiver burnout and overall health continues to be a significant issue (Saban et al., 2013), with caregivers of individuals with more severe injuries experiencing increased burden and unmet needs (Kjeldgaard et al., 2023); therefore, it is important to evaluate the long-term impact of caregiving and provide educational and support services to help caregivers effectively cope and provide better care for survivors of moderate to severe ABI.

Social Support Groups

The need for social relationships and support systems for caregivers has been reported in several studies. Caregivers who receive less social support typically feel more burdened and isolated (Acord-Vira et al., 2022; Chronister et al., 2016; Coy et al., 2013; Davis et al., 2009; Liu et al., 2015; Manskow et al., 2015; Stevens et al., 2013). Interventions of support directly address this need by providing group or individual program sessions for individuals with ABI and their caregivers.

TABLE 29 | Social Support Groups for Caregivers of Individuals with ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Niemeier et al. (2019) USA RCT PEDro=4 $N_{Initial}$=93, N_{Final}=54	**Population:** TBI; Patient Gender: Male=70, Female=23; Caregiver Gender: Male=17, Female=76; *Treatment Group (n=42)*: Mean Age= 50.4yr (41.7, 56.6); Relation: Parent=12, Spouse=15; Other=15. *Control Group (n=51)*: Mean Age= 51.4yr (46, 59.7); Relationship to Patient: Parent=22, Spouse=17, Other=12. **Intervention:** Patients and caregivers were enrolled. The Treatment Group received five 1h sessions of manualized caregiver intervention with educational, stress and anxiety self-management, coping, and emotional support components. The Control Group received educational materials. Outcome measures were assessed at pre-treatment, post-treatment, and 3-mo follow-up. **Outcome Measures**: Family Needs Questionnaire-Revised (FNQ-R), Brain Injury Caregiver Knowledge Assessment, Zarit Burden Interview, and Brief Symptom Inventory-18 (BSI-18).	1. Treatment Group caregivers showed a significant increase in met needs for emotional (FNQ-R; p<.001), instrumental (FNQ-R; p=.003), and professional support (FNQ-R; p=.014) from baseline to posttreatment, whereas Controls did not (p>.05). 2. Treatment Group caregivers showed significant improvement in brain injury knowledge from baseline to posttreatment (p<.001), whereas Controls did not (knowledge assessment; p>.05). 3. Between-group differences were significant for only emotional support needs (p=.002). 4. No differences between posttreatment and baseline were observed for any other outcome measures (p>.05). 5. Treatment effects were not sustained at 3-mo follow-up (p>.05).
Rivera et al. (2008) USA RCT PEDro=5 N=67	**Population:** Caregivers of individuals with TBI; Gender: Male=4, Female=63. *Problem Solving Group (n=33):* Mean Age=51.3yr. *Education-only Group (n=34):* Mean Age=50.8yr. **Intervention:** Caregivers were randomly assigned to a Problem-Solving Therapy Group that received 4 home visits with a staff member (at 1, 4, 8 and 12mo) or an Education-Only Group that received brief monthly calls. **Outcome Measures:** Centre for Epidemiologic Studies Depression Scale, Satisfaction with Life Scale, Pennebaker Inventory of Limbic Languidness, Caregiver Burden Scale, and Social Problem-Solving Ability.	1. A significant linear increase in depression over time was observed among the Education-Only Group (p<0.05) but a significant decrease was seen in the Problem-Solving Group (p<0.01). 2. Both groups had a significant linear increase in well-being (p<0.005). 3. There was no statistically significant interaction between treatment and time for caregiver well-being or caregiver burden. 4. There was a significant decrease in health complaints by those in the Problem-Solving Group (p<0.05). There was a decline in dysfunctional problem solving for the Problem-Solving Group (p<0.01).
Brown et al. (1999) Canada PCT N=91	**Population:** Caregivers of individuals with ABI; Mean Age=47.9yr; Gender: Male=11, Female=80; Relation: Spouse=46, Parent=35, Child=5, Unknown=5. **Intervention:** Caregivers were assigned to a traditional face-to-face on-site support group (Control, n=39) or a telephone support group using teleconference technology (Treatment, n=52). Sessions were 1.5-2 hr/wk for 9-10 wk.	1. The Treatment Group reported less burden than the Control Group on total CBI and on each subscale except social burden (all p<0.001). 2. On the POMS, the Control Group reported more distress than those in the Treatment Group (p<0.05).

Author Year Country Study Design Sample Size	Methods	Outcome
	Outcome Measures: Family Assessment Device, Caregiver Burden Inventory (CBI), Profile of Mood States (POMS).	3. For both groups, there was significant improvement in mood scores (POMS, $p<0.05$).
Acorn (1995) Canada Pre-Post N=19	**Population:** Caregivers of individuals with head injury; Mean Age=50yr; Gender: Male=5, Female=14. **Intervention:** Caregivers attended a weekly group-support program (5 hr/day for 3wk). **Outcome Measures:** Dupuy General Well-Being Scale, 13-item Life Satisfaction Index Z, Rosenberg's 10-item Self-esteem Scale, Jalowiec Coping Scale Revised.	1. There were no statistically significant differences between pre- and post-intervention in coping, self-esteem, life satisfaction or well-being. 2. Participants significantly increased their use of supportive coping styles after attending the program ($p<0.05$).

Discussion

Support groups provide an opportunity for caregivers to learn from and converse with other caregivers of individuals with ABI. In a pre-post study, Acorn (1995) found that weekly support groups did not improve mental well-being, including coping, self-esteem, and life satisfaction. However, participant significantly increased their use of coping styles after the intervention. In a PCT study by Brown et al. (1999), caregivers attending a telephone support program reported less burden and distress than those attending an on-site support group.

In the RCT by Rivera et al. (2008), caregivers benefited form a program that incorporated educational, skill building, emotional support, and problem-solving training components. Rivera et al. (2008) compared caregivers who received problem-solving therapy to those who received only education. The treatment group showed significant decreases in depression, health complaints, and dysfunctional problem solving; however, no treatment and time interactions were found for caregiver well-being or burden (Rivera et al., 2008). Likewise, in an RCT, Niemeier et al. (2019) examined a manualized caregiver intervention with educational, coping, skill building, and emotional support components, while patients and caregivers in the control group received standard care. The authors found that caregivers showed a greater decrease in emotional burden and improvement in brain injury related knowledge post-treatment than those who received education materials alone; however, these gains were not sustained at 3-month follow-up. (Niemeier et al., 2019).

Conclusions

There is level 2 evidence (Rivera et al, 2008) that problem-solving therapy may improve depression, health complaints, and dysfunctional problem solving, but not well-being or burden, compared to an educational program in caregivers of individuals with ABI.

There is level 2 evidence (Brown et al., 1999) that telephone support groups may reduce burden and distress compared to traditional face-to-face on-site support groups in caregivers of individuals with ABI.

There is level 2 evidence (Niemeier et al., 2018) that a manualized caregiver intervention with educational, self-management, coping, and emotional support components may reduce emotional burden and improve brain injury knowledge in caregivers of individuals with moderate to severe TBI.

There is level 4 evidence (Acorn, 1995) that on-site support groups may not improve well-being, life satisfaction or self-esteem in caregivers of individuals with head injury. However, these groups may improve the use of supportive coping styles.

KEY POINTS

- Social support groups, delivered via video or telephone, as well as problem-solving interventions may improve outcomes in caregivers of individuals who sustained a moderate to severe ABI.

Educational Interventions

Education and access to information have been found to have a positive effect on caregiver burden. Caregivers regard health information support as a valuable resource, particularly in the early stages of TBI care (Calvete & de Arroyabe, 2012; Liu et al., 2015). The needs of family caregivers are very complex and can be impacted by several factos, such as the age and gender of the caregiver, the severity of the injury the patient sustained, as well as the relationship to the patient, with potential differences in caregiving needs for spouses and parents (Ennis et al., 2013). Therefore, it is critical to tailor information to specific needs of families and provide meaningful education on brain injury and its sequelae.

TABLE 30| Educational Interventions for Caregivers of Individuals with ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Brown et al. (2015) USA RCT PEDro=8 $N_{Initial}$=257, N_{Final}=215	**Population:** TBI=144, Family Members Of Individuals With TBI=113; *Treatment Group (n=129):* Mean Age=48.6yr; Gender: Male=51, Female=78; Time Post Injury= >1yr; Severity: Moderate-to-Severe=69. *Control Group (n=128):* Mean Age=47.2yr (19.9, 86.4); Gender: Male=46 Female=82; Time Post Injury= >1yr; Severity: Moderate-to-Severe=75	1. Curriculum based training in advocacy skills did not significantly improve behavioral measures of advocacy skills compared to self-directed training (ABRS; p>.05). 2. When groups were combined and intervention type was not considered,

Author Year Country Study Design Sample Size	Methods	Outcome
	Intervention: Participants were randomly allocated to a curriculum-based or self-directed advocacy training group that focused on gaining skills to access services, funding, and other supports for living and working, to increase self and community awareness about TBI, initiating and tracking service and policy changes, improving the ability of others to obtain access to community life and successful living. Both groups met on the same day once per month for 4mo. Outcome measures were assessed prior to participation in the first program or self-directed training sessions and at the end of the last training session. **Outcome Measures:** Written self/systems advocacy, Verbal self/systems advocacy, Advocacy Behaviour Rating Scale (ABRS).	behavioral measures of advocacy significantly improved post intervention (ARBS; p<.001).
Sinnakaruppan et al. (2005) UK RCT PEDro=5 $N_{Initial}$=89, N_{Final}=83	**Population:** TBI=41, Caregivers=42; Age Range=21-63yr; Gender: Male=41, Female=42. Time Post Injury=2 to 94mo. **Intervention:** Caregivers and patients were randomly assigned to an educational training program covering memory, executive function and emotions led by a neuropsychologist (Treatment, 8 x 2.5 hr sessions) or a waitlist (Control). **Outcome Measures:** Hospital Anxiety and Depression Scale (HADS), General Health Questionnaire-28 (GHQ), Rosenberg Self-Esteem Scale, COPE Scale, Functional Independence Measure (FIM), Rivermead Behavioural Memory Test (RBMT), Behavioural Assessment of Dysexecutive Syndrome (BADS), Weschler Adult Intelligence Scale-Third Edition (WAIS).	1. For caregivers, the Treatment Group had significantly decreased GHQ-Depression scores than Controls (p=0.044), but no significant differences were found on the HADS. 2. Total FIM mean differences were greater for caregivers in the Treatment Group than in the Control Group (p=0.036). 3. Caregivers in the Treatment Group had greater improvements in seeking instrumental social support (p=0.04) and behavioral disengagement (p=0.016) than Controls. 4. Patients in the Treatment Group showed greater mean score changes on the WAIS vocabulary (p=0.02), RBMT profile (p=0.04) and screening (p=0.034), and BADS (p=0.043) than Controls.
Carnevale et al. (2002) USA RCT PEDro=5 N=27	**Population:** ABI=27; TBI=18; Anoxia=5, Arteriovenous malformation=1, Stroke=1, Encephalopathy=1, Electrocution=1; Mean Age=38.9yr; Gender: Male=18, Female=9; Mean Time Post Injury=8.7yr. **Intervention:** Participants with ABI and their caregiver (27 pairs) were randomly assigned to the control group (n=10), education group (2 hr/wk, 4 wk; n=8) or education plus behavioural management group (n=9). The intervention (8 wk) was the development and implementation of individualized treatment plans. **Outcome Measures:** Questionnaire on Resources and Stress for Families with Chronically Ill or Handicapped Members (QRS), Adapted Version of the Maslach Burnout Inventory (MBI).	1. **Limited statistics provided in study.* After adjustment for baseline burden and stress ratings, an analysis of covariance found that there were no significant differences after treatment on the QRS and MBI.

Author Year Country Study Design Sample Size	Methods	Outcome
McDonald et al., (2021) Australia Pre-post N=6	**Population:** TBI=5, Stroke=1; Caregivers (n=6): Gender: Female=6, Male=0; Mean Age= 54.3yr. Person with ABI (n=6) Gender: Female=0, Male=6; Mean Age= 3yr; Injury severity=Moderate-Severe; Mean Time Post Injury=5.3yr **Intervention:** Participants received an On-line psychoeducation programme for family member, families and/ or caregivers to provide support and training in behaviour management and caring for an adult with TBI for 20-60 mins/ module x7wk and one wk for practicing skills. The total duration was 8 wk. **Outcome Measures:** Credibility/Expectancy Questionnaire (CEQ); Overt Behaviour Scale-Adult (OBS-Adult); Treatment Acceptability Questionnaire (TAQ); Depression Anxiety and Stress Scale (DASS-21); Carer Strain Index (CSI); Social Problem Solving Inventory – Revised 10 Item Scale (SPSI-R-10); Family Assessment Device-General Functioning subscale (FAD-GF); The Family Environment Scale (FES) Form R.	1. No significant change was observed in levels of distress and strain index in care givers at the post-treatment time point. 2. While caregivers had challenges regarding problem solving and family function, there was no significant improvement at post-test time point. 3. Lack of change in overt scores for challenging behaviors on the OBS and in the relative stability of mood, problem solving and family function (with a few exceptions).
Geurtsen et al. (2011) Netherlands Pre-Post $N_{Initial}$=41, N_{Final}=38	**Population:** Caregivers of Individuals with chronic ABI=41; Mean Age= 47.9±8.3yr; Gender: Male=13, Female=28, Relationship to Patient: Parent=33, Spouse=6, Sibling=2 **Intervention:** Participants took part in the Brain Integration Program. Caregivers received individual education about brain injury and its behavioural consequences. They also received psychosocial support through individual counselling and information from rehabilitation nurses through regular phone calls, when necessary. Outcome measures were assessed at inclusion (T0), the start of the treatment 3mo later (T1), the end of the treatment (T2) and 1yr follow-up after the end of treatment (T3). **Outcome Measures**: Involvement Evaluation Questionnaire for Brain Injury (IEQ-BI), General Health Questionnaire (GHQ), Family Assessment Device (FAD)	1. Participants showed significant improvement in emotional burden at follow-up compared to at inclusion (IEQ-BI Sum score; p=.004; IEQ-BI Tension subscale; p=.048; IEQ-BI Worrying subscale; p=.028, IEQ-BI Urging subscale; p=.001). 2. Participants showed significant improvement in psychological health at 1yr follow-up (GHQ; p=.016). No significant changes were found immediately after treatment for any outcome measures (p>.05).
Sander et al. (2009) USA Post-Test $N_{Initial}$=15, N_{Final}=15	**Population**: Caregivers of Individuals With TBI=15 (Caring for A Patient with Severe TBI=9); Median Age=45yr; Gender: Female=12, Male=3; Relationship with Patient: Parent=11, Spouse/Significant Other=3, Other=1 **Intervention**: Participants completed six web-based videoconference sessions that combined didactic education and interactive problem-solving. The sessions were administered on an individual basis and addressed the following types of neurobehavioral problems post TBI: General education on TBI and its	1. Participants' overall satisfaction and comfort with the training was high, with 75-100% of participants indicating that the amount of information presented in each session was "just right" and each program session was helpful. 2. Participants perceived that they gained knowledge that was applicable to the everyday problems being experienced. At follow-up, all participants reported having used the knowledge gained to help

Author Year Country Study Design Sample Size	Methods	Outcome
	consequences, reduced awareness, reduced memory and attention, changes in language and social communication, reduced initiation and organization, changes in emotions and behaviour. Outcome measures were assessed immediately following training and at an average of 18mo after training. **Outcome Measures**: Satisfaction survey, follow-up interview with questions about the helpfulness of the intervention.	cope with problems and all had referred to the written materials at least once since the training.

Discussion

Several studies examined whether an educational intervention was effective for promoting psychological well-being and reducing emotional burden in caregivers of individuals with ABI. In an RCT by Brown et al. (2015), participants were randomly allocated to a curriculum-based or self-directed advocacy training group that focused on gaining skills related to accessing services, funding, and other supports for living and working, and increasing self and community awareness about TBI, among other skills for successful living. The authors found that curriculum based training in advocacy skills did not significantly improve behavioral measures of advocacy skills compared to self-directed training (Brown et al., 2015).

In an RCT, Sinnakaruppan et al. (2005) found that education can have a positive effect on depression, as measured by the General Health Questionnaire; however, these effects were not seen on the HADS measure within the same study and should be interpreted with caution. In a pre-post study, Geurtsen et al. (2011) reported that an educational intervention along with psychosocial support provided through counselling reduced emotional burden and improve psychological health in caregivers of individuals with chronic ABI at 1-year follow-up. Besides psychological well-being, educational interventions can also help caregivers acquire ABI-related knowledge that is applicable to everyday situations. In a post-test study by Sander et al. (2009), after completing six web-based videoconference sessions that combined didactic education and interactive problem-solving, caregivers of individuals with TBI indicated that they had gained knowledge applicable to the everyday problems being experienced. In addition, at 18-month follow, all participants reported having used the knowledge gained during the intervention at least once to help cope with problems that they had encountered (Sander et al., 2009).

Some studies provided rehabilitation to the individual with an ABI as well as educational intervention for the caregiver. In an RCT, Carnevale et al. (2002) found that there was no difference in family stress or potential burnout post education and behavioural management training compared to caregivers just receiving education. In the RCT by Brown et al. (2015), those with moderate-to-severe TBI and their

caregivers received curriculum-based or self-directed advocacy training. The researchers found that both types of interventions significantly improved advocacy skills in participants, and no intervention type was superior to the other in terms of its effectiveness (Brown et al., 2015).

Conclusions

There is 1b evidence (Brown et al., 2015) that curriculum-based advocacy training was not superior to a self-directed approach in improving advocacy behavior in individuals with moderate to severe TBI and their caregivers.

There is level 2 evidence (Sinnakaruppan et al., 2005) that educational training programs may reduce depression among caregivers of individuals post ABI. However, this result needs to be interpreted with caution as it was not demonstrated consistently across all measures of depression that were reported by the study.

There is level 2 evidence (Carnevale et al., 2002) that providing education to a caregiver as well as behavior management for the individual with an ABI may not be more effective for improving family stress or burnout risk compared to education alone.

There is level 4 evidence (Geurtsen et al., 2011) that the provision of education and counselling may reduce emotional burden and improve psychological health in caregivers of individuals with chronic ABI.

There is level 4 evidence (Sander et al., 2009) that web-based videoconference education interventions may improve coping and problem-solving in caregivers of individuals with TBI.

KEY POINTS

- Educational interventions may improve outcomes for caregivers of individuals with moderate to severe TBI, including psychological health, coping, problem-solving and emotional burden.

Psychotherapy

Families of individuals with ABI may experience significant distress and anxiety related to the neurobehavioral sequalae of ABI in their loved ones; therefore, psychotherapy may be beneficial to help families adapt to the complexities of caring for an individual with ABI (Klonoff, 2014).

TABLE 31| Psychotherapy for Caregivers of Individuals with TBI

Author Year Country Study Design Sample Size	Methods	Outcome
Hadavand et al. (2022) Iran RCT PEDro=6 N=40	**Population:** Severe TBI; *ACT intervention (n=20)*; Gender: Male=4, Female=16; Mean Age=32.3yr. *Waitlisted control (n=20)*; Gender: Male=0, Female=20; Mean Age=32.7yr; Mean Time Post-Injury=Not reported. **Intervention:** Group acceptance and commitment therapy (ACT) was provided to families to assist with experiential avoidance and anxiety when caring for individuals with severe TBI. The intervention occurred for 60min, 1x/week, for 10 wk. Outcome measures were assessed at 3mo and at 6mo. **Outcome Measures:** Family Assessment Devices (FAD), Experiential Avoidance in Caregiving Questionnaire (EACQ) anxiety subscale of Depression, Anxiety and Stress Scale (DASS).	1. The ACT group scored significantly higher in all 7 domains of the Family Assessment Device post intervention (p<.001) with the exception of behavioural control which did show a significant interaction. 2. Assessment of experiential avoidance (EACQ) showed the ACT group scoring less active avoidant behaviours over time with the opposite effect among the waitlisted controls (p<.001). 3. Apprehension scores also were significantly lower among the ACT intervention group at all 3 time points in comparison to the waitlisted controls (p=.013).

Discussion

In an RCT, Hadavand et al. (2022) implemented a group Acceptance and Commitment Therapy (ACT) intervention for families of individuals with severe TBI. The intervention was delivered by a clinical psychologist and sessions aimed to reduce anxiety, and experiential avoidance that may impact family functions. The authors found that a group Acceptance and Commitment Therapy (ACT) may relieve anxiety related to caring for individuals with severe TBI (Hadavand et al., 2022).

Conclusion

There is level 1b evidence (Hadavand et al., 2022) that group acceptance and commitment therapy (ACT) may help relieve anxiety and improve family function in caregivers of individuals with severe TBI.

KEY POINTS

- Group Acceptance and Commitment Therapy (ACT) may improve symptoms of anxiety and increase family function for caregivers of individuals post severe TBI.

Multimodal Interventions

Therapies may be evaluated in combination or comparatively to determine treatment effects. Commonly, studies combine educational and support interventions into a single treatment program to

improve caregiver outcomes. This is particularly beneficial because caregivers face diverse challenges, and a multimodal intervention can target more areas than a singular intervention program.

TABLE 32| Multimodal Interventions for Caregivers of Individuals with ABI

Author Year Country Study Design Sample Size	Methods	Outcome
Powell et al. (2016) USA RCT PEDro=6 N=153	**Population:** TBI Caregivers; *Control Group (n=76)*: Mean Age=51.1yr; Gender: Male=14, Female=62; Relationship to Patient: Spouse/Partner=36, Child=31, Other=9. *Intervention Group (n=77):* Mean Age=48.2yr; Gender: Male=13, Female=64; Relationship to Patient: Spouse/Partner=46, Child=23, Other=8. **Intervention:** TBI caregivers in the Intervention Group received a maximum of 10 telephone calls at 2wk intervals after discharge of the TBI patient in addition to usual care. The telephone calls combined education and mentored problem-solving on topics relevant to caregiving associated with TBI recovery and management. Participants in the control condition received usual care. **Outcome Measures:** Bakas Caregiving Outcome Scale (BCOS), Brief Symptom Inventory (BSI-18), Participation Assessment with Recombined Tool-Objective (PART-O), Modified Caregiver Appraisal Scale (MCAS), TBI Survivor Measures, Other Prespecified Caregiver Outcomes.	1. A composite outcome measure of BCOS and BSI-18 showed a significant between-group difference in favor of the Intervention Group at 6mo (p=0.032). For the BSI-18 alone, emotional well-being was significantly better in the treatment Group at 6mo (p=0.031). 2. There were no significant between group differences in PART-O or MCAS scores. 3. None of the TBI survivor measures tested (BSI, Life Satisfaction Scale) were significantly different between groups. 4. The Intervention Group differed significantly from the Control Group in support from friends and family (p=0.019), and healthcare providers (p=0.027), taking care of their own health (p=0.046), receiving help (p=0.015), more active coping (p=0.020), less emotional venting (p=0.028), and less use of humour (p=0.011).
Kreutzer et al. (2015) USA RCT PEDro=4 $N_{initial}$=137, N_{final}=104	**Population:** Caregivers of Individuals with TBI; Median Age=51.4yr; Gender: Male=38, Female=99; Relation: Parents=51, Spouses=56, Other=30. **Intervention:** Caregivers of individuals with TBI were randomized into the Brain Injury Family Intervention (BIFI) program which includes family education, skill building, and psychosocial support (treatment, n=80) or a waitlist (Control, n=24). The BIFI group completed 5 sessions over 10 wk. Assessments took place at baseline, 10 wk and 3mo. **Outcome Measures:** Family Needs Questionnaire (FNQ), Service Obstacles Scale (SOS), Zarit Burden Inventory (ZBI).	1. There was a significant improvement in Health Information (p=0.003), Emotional Support (p=0.0001), Professional Support (p=<0.0001) and Community Support (p=0.0179) subscales of the FNQ from baseline to 10 wk for the BIFI group; however, there was no significant difference in Instrumental Support (p=0.5292) or Care Involvement (p=0.0646). 2. Only Emotional Support (p=0.0184) and Professional Support (p=0.0022) subscales of the FNQ remained significant at 3mo follow-up for the BIFI group. 3. Both SOS and ZBI scores improved in the BIFI group from baseline to 10 wk (p=0.0036 and p=0.0007, respectively). 4. There was no significant difference in FNQ, SOS or ZBI scores in the Control Group from baseline to 10 wk (all p>0.05).

Author Year Country Study Design Sample Size	Methods	Outcome
Gerber & Gargaro (2015) Canada Pre-Post $N_{initial}$=78, N_{final}=61	**Population:** TBI=26, CVA=20, Anoxia=8, Tumor=7; Mean Age=44.97yr; Mean Time Post Injury=7.71yr; Severity: Mild=5, Moderate=48, Severe=9. **Intervention:** Participants entered a multi-faceted day program with their caregivers (2 d/wk, 6mo). Programme activities included exercise (walking and yoga), discussion groups (newspapers and current events) and workshops, hobbies (gardening), crafts and games and skill training sessions on topics such as relaxation techniques, managing emotions and health and wellness education. **Outcome Measures:** Community Integration Questionnaire (CIQ), Overt Behaviour Scale (OBS), Burden Assessment Scale (BAS), Goal Attainment Scale (GAS).	1. Mean CIQ was significantly higher after 6mo of intervention (10.02 to 12.25, p=0.000). 2. Mean BAS was significantly lower after 6mo of intervention (48.83 to 45.40, p=0.006). 3. Mean OBS was lower after 6mo of intervention (7.08 to 5.66) but the difference was not statistically significant. 4. OBS was positively correlated with BAS at baseline (r=0.381, p=0.006) and at 6mo (r=0.391, p=0.006). 5. BAS at baseline (r=-0.409, p=0.004) and at 6mo (r=-0.302, p=0.032) was negatively correlated with CIQ at 6 mo.
Kreutzer et al. (2010) USA PCT $N_{Initial}$=152, N_{Final}=152	**Population**: ABI=76, Caregivers of Individuals with ABI=76. *Individuals with ABI:* Mean Age= 43.2±14.80yr; Gender: Male=45, Female=31; Mean Time Post Injury=30.2±42.84mo, Severity: Mean GCS=9.6. *Caregivers:* Mean Age= 50.9±13.43yr; Gender: Male=23, Female=53; Relationship to Patient: Spouse=51%, Parent=34%, Other=15% **Intervention:** Participants received the Brain Injury Family Intervention (BIFI), a structured family intervention program which includes educational, skill building, and psychological support components. The BIFI consisted of five 2h sessions over 10wk. Outcome measures were assessed following each session and following completion of the entire program. **Outcome Measures:** The Learning Survey (assesses perceptions of goal attainment and helpfulness of each session), Session Report Form, Program Satisfaction Survey, Overall Program Helpfulness scale.	1. Ratings of Overall Program Helpfulness were high for both patients and caregivers, with 71% of patients and 89% of caregivers rating the program as “very helpful” (Program Satisfaction Survey). 2. Across program sessions, 85% of patients and 92% of caregivers agreed that their program goals were met (The Learning Survey). 3. No significant differences were observed for individual session helpfulness or goal attainment ratings between patients and caregivers (p>.05).
Kreutzer et al. (2009) USA Pre-Post N=53	**Population:** Caregivers of Individuals with ABI; Mean Age=50.22yr; Gender: Male=18, Female=35; Relation: Spouse=29, Parent=15, Other=9. **Intervention:** Caregivers and patients participated together in the Brain Injury Family Intervention (BIFI) program (2 hr sessions 5x/wk over 10 wk) based on family systems theory and cognitive behavioural therapy. The program consists of education, skill building, and psychosocial support. **Outcome Measures:** Family Needs Questionnaire (FNQ), Service Obstacles Scale (SOS), Family Assessment Device (FAD), Brief Symptom Inventory (BSI), Satisfaction with Life Scale (SWLS).	1. Scores on all FNQ subscales changed significantly from pre to post (p≤0.0346) and pre to 3mo follow-up (p≤0.0024). 2. Scores on the FAD assessment tool did not change over time, whereas scores on the SOS did change significantly over time (p=0.0004). 3. Results of the BSI and the SWLS did not show any significant changes over time.
Smith et al. (2006) UK	**Population:** Caregivers for Individuals with ABI; Relation: Parent=18, Partner=23; Gender: Male=9,	1. The mean proportion of met family needs was significantly different between the

Author Year Country Study Design Sample Size	Methods	Outcome
Case Control N=41	Female=32. *Community Group (n=17):* Mean Age=48.3 yr; *Outpatient Group (n=24):* Mean Age=49.3 yr. **Intervention:** Caregivers of individuals who attended a community rehabilitation service were compared to caregivers whose individual with ABI attended a traditional outpatient service. **Outcome Measures:** Family Assessment Device-General Functioning (FAD-GF), Family Needs Questionnaire, General Health Questionnaire, Acceptance and Action Questionnaire.	Outpatient Group (30.63) and the Community Group (61.12, p=0.02). 2. The mean FAD-GF score for the Outpatient Group was significantly higher than the Community Group (2.03 vs. 1.74; p=0.04), indicating higher levels of maladaptive familial interaction in the Outpatient Group.

Discussion

In an RCT, Powell et al. (2016) examined an intervention for caregivers delivered via telephone, including education, problem-solving, and topics associated with caregiving post TBI. The authors reported that, at six months post ABI, caregivers were able to increase their involvement in recreational and professional endeavors; at this time, continuing concerns expressed by caregivers included emotional adjustment, time management, and creating healthy habits (Powell et al., 2016). In a pre-post study Kreutzer et al. (2009) studied families who participated in a Brain Injury Family Intervention program that focused on cognitive behavioural therapy and education on family dynamics (e.g., managing stress). The authors found that family members benefited in terms of meeting needs and overcoming service obstacles, although the program did not strongly improve their family functioning, life satisfaction, or psychological well-being. In another study involving participants of the same intervention program, caregivers perceived the intervention as helpful and agreed that their program goals were met (Kreutzer et al., 2009). In a subsequent RCT study, Kreutzer et al. (2015) implemented a family Intervention program which included family education, skill building, and psychosocial support. The authors found significant improvements in the family needs questionnaire; however, no differences in the Zarit Burden Inventory were observed (Kreutzer et al., 2015).

In a pre-post study, Gerber & Garagaro (2015) examined the effectiveness of a multifaceted day program for individuals with ABI and their caregivers that included exercise activities, social activities and wellness education. The authors found improvements in social integration and a lower level of caregiver burden six months post intervention (Gerber & Gargaro, 2015). In a case control study, Smith et al. (2006) found that home-based community rehabilitation services for individuals with ABI resulted in more favourable outcomes for carers in terms of fulfilled family needs and family functioning when compared to traditional outpatient services. Based on the studies above, multimodal interventions appear to have the strongest evidence for community reintegration post ABI. As social integration encompasses many

different aspects of life and functioning, multimodal interventions can provide the broadest level support to address these components.

Conclusions

There is level 1b evidence (Powell et al., 2016) that a telephone delivered intervention after discharge may improve emotional wellbeing in caregivers of individuals with TBI.

There is level 2 evidence (Kreutzer et al., 2010; Kreutzer et al., 2015) that a structured family intervention program with educational, skill building, and psychological support components may improve goal attainment in individuals with moderate to severe ABI and their caregivers.

There is level 3 evidence (Smith et al., 2006) that community-based rehabilitation for the individual with an ABI may be more effective than traditional outpatient services in benefiting caregivers of individuals post ABI by improving levels of met family needs and reducing family dysfunction.

There is level 4 evidence (Kreutzer et al., 2009) that the Brain Injury Family Intervention may improve met family needs and satisfaction with services and reduce burden in caregivers of individuals with TBI.

There is level 4 evidence (Gerber & Gargaro, 2015) that a multifaceted day program for individuals with TBI and their caregivers may improve social integration and caregiver burden.

KEY POINTS

- Multimodal interventions that are offered to families of individuals with moderate to severe ABI may result in improved social integration and reduced caregiver burden.

Conclusion

Community reintegration is a critical aspect of rehabilitation for individuals with moderate to severe ABI, and it relates to the individual's social activities, ability to live independently and return to, or find employment (Truelle et al., 2010). Community integration post ABI is a complex and multidimensional process that that can be influenced by including injury-related, social and environmental factors, as well as personal factors such as self-awareness, motivation and coping (Shaikh et al., 2019). Community reintegration may look different for each individual and it may vary depending on age; for instance, older adults may experience a significant decrease in social engagement and are more likely

to be retired or unemployed, compared to younger age groups (Ritchie et al., 2014). Rehabilitation interventions need to reflect that by using patient-centered, personalized, multifaceted approaches to address the unique needs of individuals who have sustained a moderate to severe TBI.

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