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Technology-Based Approaches to Improve Mental Health Outcomes for Patients with Traumatic Brain Injury

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1. Introduction

Every year approximately 1.4 million people sustain a traumatic brain injury (TBI) in the United States (Langlois J.A. et al., 2006). Mental health disorders such as depression, anxiety, and post-traumatic stress disorder are commonly observed in these individuals. The prevalence of depression following TBI has been reported to range from 14-77% (Ashman et al., 2004). The rate of major depressive disorder within the first year after TBI is 7.9 times greater than in the general population (Bombardier et al., 2010). Mental health conditions can affect the individual for years, even decades after the initial trauma (Dikmen et al., 2004; Holsinger et al., 2002). Further, depression after TBI can lead to worse global outcomes (Fedoroff et al., 1992), poorer social functioning (Bourdon et al., 1992; Jorge et al., 1993; Schoenhuber & Gentilini, 1988), lower health-related quality of life, including an inability to return to work (Christensen et al., 1994; Rutherford, 1977), and suicide (Hesdorffer et al., 2009).

Post-TBI mental health conditions must be treated promptly as they can impair individuals from engaging in the rehabilitation process: these individuals experience poorer recoveries compared to individuals with TBI without mental health conditions (McAllister & Arciniegas, 2002; Mooney et al., 2005; Mooney & Speed, 2001). Although mental health disorders are a major cause of disability, many individuals, particularly those with depression do not receive adequate treatment (Andrews & Henderson, 1999; Bebbington et al., 2000; Kessler et al., 2001). One strategy to address this problem has been the development of technology-based mental health treatment programs. The recent widespread adoption of various computers and handheld devices in everyday life activities presents an opportunity to examine how these technologies can best facilitate various types of mental health treatments for individuals with TBI. Such programs utilize established and emerging technologies such as the Internet, handheld devices, downloadable computer programs, telephones, virtual reality, and video conferencing. In addition to providing an adjunct to traditional psychotherapy, technology-based approaches have the potential to deliver self-help interventions to people who do not seek or receive help for their condition (Kaltenthaler et al., 2002; Proudfoot et al., 2003). Further, technology-based treatment programs may have several advantages compared to conventional psychotherapy (Christensen & Griffiths, 2002; Garcia et al., 2004; Gega et al., 2004):

- they can reach a mass audience;
- they are likely to be cost-effective;
- they are capable of supporting individually tailored programs: users can take assessments and complete interactive workshops at their own pace;
- they are capable of supporting automated applications that guarantee intervention fidelity;
- they provide a convenient platform for delivering booster sessions;
- unlike most if not all clinic settings with predetermined hours of operation, such resources are available around the clock;
- they can be conveniently accessed from home, eliminating transportation difficulties and addressing lack of access to face-to-face mental health services in rural areas;
- they are available immediately: the demand for treatment for anxiety and depressive disorders exceeds the supply of suitably trained therapists, so waiting lists are often long;
- they can be delivered privately and anonymously: many sufferers prefer to avoid the stigma commonly incurred by seeing a therapist.

For people with TBI, the potential to use technology-based approaches to self-treat has several additional advantages. Often, victims of TBI are young and may be more familiar with technology-based approaches and may prefer using them to traditional psychotherapy. Further, the fact that individuals can access the Internet and other technologies from their home renders this medium more accessible, cheaper and private. Accessibility is particularly important for these individuals as many of them may also have additional injuries affecting mobility and their depressed mood and anxiety may decrease their motivation to leave the home to seek therapy.

This first objective of this chapter is to describe the results of a scoping review of the literature related to the implementation of technology based approaches for mental health care of patients with TBI and their families/caregivers. The second objective is to present the results of an original survey of TBI patient attitudes towards technology based-approaches to mental health care.

2. Background

Technology-based approaches to mental health treatment are effective, accessible and available means of relaying information or therapeutic interventions to individuals in the population. At present, there is a multitude of *informational* Internet sites that provide a rich variety of resources related to depression, anxiety, post-traumatic stress disorder and other mental health conditions (Griffiths et al., 2009; Ipser et al., 2007; Szumilas & Kutcher, 2009). Such information portals typically target the general user population. Additionally, Internet-based *treatment programs* have emerged in the last decade. Examples of such programs include treatment for insomnia (Ritterband et al., 2009; Strom et al., 2004), excessive alcohol consumption (Linke et al., 2004), panic disorder (Carlbring et al., 2003), post-traumatic stress disorder (Knaevelsrud & Maercker, 2007), social phobia (Andersson et al., 2006), smoking cessation (Feil et al., 2003), headache (Andersson et al., 2003), assertion training and stress management (Yamagishi et al., 2007), and tinnitus (Andersson & Kaldø, 2004).

Although these have primarily been feasibility studies, some have reported successful treatment outcomes (e.g. (Knaevelsrud & Maercker, 2007; Knaevelsrud & Maercker, 2009). Griffiths and colleagues (Griffiths et al., 2010) recently published a review of all the available

randomized control trials (RCTs) of internet-based interventions for depression: the first trial was published in 2002 (Clarke et al., 2002), with nine additional trials published in the subsequent years (Billings et al., 2008; Christensen et al., 2004; Clarke et al., 2005; Meyer et al., 2009; Patten, 2003; Perini et al., 2009; Spek et al., 2007; van Straten et al., 2008; Warmerdam et al., 2008). Seven of the trials were community based (Christensen et al., 2004; Meyer et al., 2009; Patten, 2003; Perini et al., 2009; Spek et al., 2007; van Straten et al., 2008; Warmerdam et al., 2008), two were undertaken in the context of a health care organization (Clarke et al., 2002; Clarke et al., 2005), and one in the workplace (Billings et al., 2008). The sample sizes ranged from 48-786 patients with an average age of the participants from 30-50 years. Seven of the trials demonstrated efficacy of the intervention with effect sizes ranging from 0.42 to 0.65 as compared to placebo or wait list controls (Griffiths et al., 2010). Only four of the depression-related websites reviewed were available in the English language: ODIN, MoodGYM, and Bluepages are publicly accessible on the web without charge to consumers and the fourth program, Sadness, is available under restricted license at a small cost. All of the programs employ at least some component of cognitive behavioural therapy (CBT).

While some of these evaluations of technology-based treatment programs have demonstrated positive results on mental health outcomes, the extent of work in this area is limited when the focus is set on the TBI population. As summarized in the following section, very few technology-based resources have been developed and evaluated specifically for the TBI patient.

3. Scoping literature review

This section will present the results of a scoping literature review that aimed to identify the current state of progress in the implementation of technology-based approaches for mental health treatment in patients with TBI. Given the limited amount of literature identified for the TBI patient alone, the scope of the review was expanded to include interventions targeted for the patient's family/caregiver as family conflict due to caregiver burden may impact a TBI patients' quality of life and rehabilitation success. In addition, studies of both adult and pediatric populations were included. We will first summarize the preliminary feasibility and pilot studies. Next, studies describing the evaluation of the intervention using validated mental health outcome measures will be presented.

3.1 Methods used for the scoping literature review

The literature review identified peer-reviewed studies using the phrases of "traumatic brain injury", "mental health", "depression", "anxiety", "post-traumatic stress disorder", "mood disorder", "technology", "Internet", "telephone", "telemedicine", and "ehealth". The exclusion criterion was publication prior to the year 2000. Searches were conducted using PubMed, CINAHL, ProQuest, PsychINFO, Web of Science, and Google Scholar. The reference lists from identified studies were also reviewed. Case studies, pilot/feasibility studies, and randomized controlled trials were all included in the review. Since only a few studies specifically focused on the TBI patient, studies with a focus on the caregiver or family of the TBI patient were included as well. The following elements were extracted from each article: patient descriptors, sample size, treatment descriptors, outcome measures collected, and results summary. Articles were grouped in two categories: 1. *preliminary feasibility studies* (i.e. those that evaluated the ease of use and/or acceptability of the

intervention); 2. *efficacy studies* (i.e. those that evaluated the effectiveness of the intervention using a validated mental-health outcome measure).

Two reviewers concurrently reviewed the title, abstract, and results of each study yielded by the search to determine eligibility of each study. A third reviewer conducted an independent evaluation of the eligibility of the articles. Attempts were made to contact the corresponding authors of the identified articles to ensure that all of their relevant work was captured, and to ascertain whether they had any relevant unpublished, or in-press articles.

Each of the second category of articles (efficacy studies) were classified according to the American Academy of Neurology (AAN) levels of scientific evidence: *level I* included prospective, randomized, controlled clinical trials that controlled for drop-outs, had clear inclusion and exclusion criteria, and presented clear baseline characterization of the patient population; *level II* included prospective, randomized, controlled clinical trials that did not meet the criteria for level I; *level III* included controlled trial studies of natural history where the outcome assessment was independent of the treatment; and *level IV* included all uncontrolled studies, case studies, and expert opinions (Ben-Menachem, 2005).

3.2 Results of the scoping literature review

3.2.1 Feasibility studies

The earliest feasibility studies in this field focused on the utilization of technology for the mental health treatment of the *caregivers* of TBI patients. Depression occurs not only in individuals with TBI, but it also frequently occurs in their caregivers (Harris et al., 2001). Family dysfunction has also been associated with post-TBI depression (Groom et al., 1998). By using behaviour coping strategies and problem solving, family dysfunction after TBI can be ameliorated (Leach et al., 1994).

Five published articles were identified which described the feasibility of implementing technology-based treatment programs for patients with TBI. These studies utilized telephone, Internet, computer, and video conferencing technologies (see Table 1 for summary).

Rotondi and colleagues examined the feasibility of using an interactive web-based intervention as a resource for psycho-social information and support for female spouses of patients with TBI (Rotondi et al., 2005). Seventeen spouses used the website for six months. The website offered them seven modules: support group, ask an expert, questions and answers library, reference library, community resources library, calendar of community events, and technical support. The interactions of the participants with the website were logged and coded for analyses. The support group module was the most used (68.6%), followed by the community services library module (20.1%). The website was used frequently over the six months of the study (838 times on average, where the median was 454 times and the range was 26-3679 times), was highly valued at the end of the period (75% found that the website was extremely satisfying and extremely helpful) and was rated as relatively easy to use (84%). The results of this study suggested that supportive and psychosocial services can be offered effectively via a website to families who have a member with a TBI. One of the strengths of the study, as discussed by the authors, was that it was the first evaluation of an online psychosocial intervention for female significant others of persons with TBI. Future work in this area would help determine and evaluate the needs of other caregivers.

A more recent study by Glang et al. examined the efficacy of an interactive multimedia CD-ROM program called Brain Injury Partners: Advocacy Skills for Parents of children who

have sustained a TBI (Glang et al., 2007). The program provided parents with information and training in educational advocacy skills. The study found a very large overall effect of the program, especially in the areas of skill application, knowledge, and attitudes. In addition, parents felt that the information was concise and useful.

Authors	Participants	Design and Intervention	Results and Conclusions
Rotondi et al., 2005	17 female spouses of individuals who sustained a TBI	Website containing seven modules: support group, ask an expert questions, questions and answers library, reference library, community resources library, calendar of community events, and technical support	75% found the website to be extremely satisfying and helpful; 84% stated that the website was relatively easy to use.
Glang et al., 2007	31 parents of children from Kindergarden to Grade 8 who had a TBI	CD-ROM programme Brain Injury Partners (control group - alternate CD-ROM)	Parents in the treatment group felt the CD-ROM was concise and useful.; significant improvements in knowledge, attitudes and application measures but not intentions and self-efficacy compared to the control group.
Bergquist et al., 2008	10 individuals with TBI and memory impairment	Internet-based cognitive rehabilitation program	All patients were able to use the program providing evidence that individuals with TBI are capable of using online resources.
Wade et al., 2009	9 families with adolescents who had a TBI	TOPS program with 10 online modules as well as video conferencing with a therapist	Website and video conferencing were rated as moderately to highly helpful and easy to use by the parents and by adolescents.
Martin et al., 2010	Military service members with moderate to severe TBI	8 weeks of telephone support from a psychiatric neuroscience nurse	93% had improvements in their symptoms compared to 84% in the control group.

Table 1. Overview of feasibility studies for family members and individuals with TBI.

Focusing on the patient with TBI, Bergquist and colleagues evaluated the potential for patients with a documented acquired brain injury and memory impairment to learn to use an Internet-based cognitive rehabilitation program (Bergquist et al., 2008). Ten individuals were trained to use an instant messaging system and were asked to participate in weekly online cognitive rehabilitation therapy sessions. The authors reported that all participants successfully learned to use the system despite their cognitive challenges.

Wade and colleagues tested the feasibility and satisfaction with an online family problem-solving intervention for adolescents who had experienced a TBI (Wade et al., 2009). Nine adolescents utilized the Teen Online Problem Solving program (TOPS), which consisted of ten web-based sessions providing information and interactive exercises on cognitive, social, and behavioral skills typically affected by TBI. Video conferences with a therapist were also made available. The participants reported that the website and videoconferences were moderately to highly helpful and easy to use for both parents and adolescents. Teen

satisfaction with the program suggested engagement in the treatment program and process. In addition, the teens stated that the mode of delivery was acceptable and the program length and structure were feasible.

Martin and colleagues demonstrated the feasibility of monitoring military service members with moderate to severe TBI via the telephone (Martin et al., 2010). The home rehabilitation program provided eight weeks of telephone support facilitated by a psychiatric neuroscience nurse. The results indicated that 93% of the participants in the telephone support group had improvements in their symptoms by the end of the study, compared to 84% in the control group (statistical significance of this finding was not indicated). Although no specific information on the types of symptoms improved was reported (cognitive, behavioral, affective, etc.) the study supported the notion that patients could be monitored safely and effectively at home via telephone.

The studies described above, and summarized in Table 1, laid the groundwork for subsequent evaluations of the efficacy of these various approaches to treatment in patients and/or their caregivers following TBI. Collectively they have demonstrated that various technologies (Internet, downloadable computer program, videoconferencing, telephone) show promise in the delivery of treatment programs that are feasible, helpful, and satisfactory for patients with TBI, including those with cognitive impairments, and their families.

3.2.2 Efficacy studies

Seven original research articles were identified that evaluated the implementation of a technology-based intervention program, and incorporated at least one validated mental health outcome measure (see Table 2 for summary). Five of the studies were randomized controlled trials (note: two articles were based on data from one study) and two were case series. Four studies reported the use of an Internet- or computer-based intervention and three reported on telephone counseling and education. Of the seven studies, four evaluated interventions specifically for the TBI patient, and three examined outcome measures in both the patient and their family members/caregivers.

Scheduled telephone counseling and education. Bell and colleagues conducted one of the early studies exploring the effectiveness of a scheduled telephone intervention on behavioral outcomes (Bell et al., 2005). The intervention offered counseling and education to patients with moderate to severe TBI. A two-group randomized prospective clinical trial was conducted with 171 participants. The control group received contact with the researchers only during the initial assessment and at the one-year follow-up interview whereas the intervention group received seven regular, scheduled telephone calls over the nine month study period. The telephone calls included motivational interviewing techniques, counseling, and education. The results of the study demonstrated better scores on the behavioral index, quality of wellbeing, and emotional state measures in the intervention group as compared to the control group. A separate analysis of the data from the study specifically focused on symptoms of depression (Bombardier et al., 2009). At the one year follow up assessment individuals in the intervention group scored significantly lower on all depression symptom measures than those in the control group. Further, in the subgroup of individuals who scored high on depression severity at baseline, those who received the intervention improved their depression scores at study completion, while the scores of those in the control group worsened.

Authors	Participants	Sample size	Design and Intervention	Outcome measures	Results	AAN level
Bell et al., 2005	Patients with moderate to severe TBI, discharged from an acute rehabilitation unit; age 36 yrs (range 18-70 yrs)	171	2-group double-blind RCT; telephone follow-up versus usual care over 9 month intervention period.	<u>primary outcome composite</u> (FIM, DRS, CIQ, FSE, GOS-E, EuroQol, NFI, PQOL, SF-36, and BSI); <u>functional status composite</u> (FIM, DRS, CIQ, FSE, GOS-E, and EuroQol.); <u>quality of well being composite</u> (PQOL and SF-36 mental subscore); BSI	▲ primary outcome composite: p=0.002, ▲ functional status composite: p=0.003, ▲ quality of well being composite: p=0.006, ▲ EuroQol: p=0.008, ▲ GOS-E: p=0.04, ■ FSE: p=n.s. ■ DRS: p=n.s. ▲ PQOL: p=0.04, ▲ SF-36 mental: p=0.01, ▲ BSI: p=0.005	I
Bombardier et al., 2009	See Bell et al., 2005	171	Secondary analysis of data from Bell et al., 2005.	BSI-D, NFI-D, MHI-5	▲ BSI-D: p=0.017, ▲ NFI-D: p=0.002, ▲ MHI-5: p=0.009	I
Bell et al., 2008	Patients with mild TBI, enrolled in the emergency department; age 32.5 yrs (SD=13 yrs)	366	2-group double-blind RCT; telephone follow-up versus usual care over 3 month intervention period.	<u>post-traumatic symptom composite</u> (Head Injury Symptom Checklist and 12 functional areas), <u>general health composite</u> (SF-12 Physical, PQOL, PHQ-Depression, PHQ-Anxiety/Panic, PHQ-Anxiety/Other, SF-12 Mental, major role and community integration)	▲ post-traumatic symptoms composite: p=0.016, ■ general health composite: p=0.417	I
Wade et al., 2005	Families with children who had moderate to severe TBI; age 9.4 yrs (range 6.7-15.8 yrs); sustained TBI 16 mo prior to enrollment (range 15-29 mo).	6 children, 8 parents, 5 siblings	Pilot case study; Family Problem Solving program (12 sessions - weekly videoconferences with a therapist and self-guided Web exercises)	PSI, FBII, SCL-GSI, CES-D, SCL-90, AI, CES-D, BRIEF GEC, CDI, HCSBS-AB	<u>Parent outcomes:</u> ▲ PSI: p<0.05, ▲ FBII: p<0.01, ▲ SCL-90: p<0.05, ■ AI: p=n.s. ▲ CES-D: p < 0.05 <u>Child outcomes:</u> ■ BRIEF-GEC: p=n.s. ■ CDI: p=n.s. ▲ HCSBS-AB: p<0.05	IV
Wade et al., 2006	Families with children who had moderate to severe TBI; age 10.8 yrs (SD 3.1 yrs); sustained TBI 13.7 mo prior to enrollment (SD 7.1 mo).	46	2-group RCT; FPS intervention (14 sessions - weekly videoconferences with a therapist and self-guided Web exercises)	SPSI-short version, SCL-90-R, GSI, CES-D, AI	<u>Parent outcomes:</u> ■ SPSI-short: p=n.s. ▲ CES-D: p<0.05, ▲ AI: p < 0.05, ▲ SCL-90-R: p<0.05	II
Wade et al., 2008	Families with adolescents who had moderate to severe TBI; age 15.0 yrs (range 11.7-18.2 yrs); sustained TBI 9.3 mo prior to enrollment (range 2-20 mo).	9 families	2- group single blind RCT (audio and non-audio groups); TOPS intervention (14 sessions - weekly videoconferences with a therapist and self-guided Web exercises)	CBCL, BRIEF GEC, CDI, SCL-90 GSI, CES-D, CBQ, Issues checklist	<u>Teen outcomes:</u> ■ CBCL: p=n.s. ▲ CBCL internalizing behavior: p=0.03, ■ BRIEF GEC: p=n.s. ▲ CDI: p=0.02, <u>Parent outcomes:</u> ■ SCL-90 GSI: p=n.s. ▲ CES-D: p=0.01 <u>Parent-teen interactions:</u> ▲ CBQ: p=0.04, ▲ Number of issues: p=0.01	IV

Authors	Participants	Sample size	Design and Intervention	Outcome measures	Results	AAN level
Topolovec-Vranic et al., 2010	Mild to moderate TBI; age 42.5 yrs (range 19.3-72.3 yrs); sustained TBI 2.1 yrs prior to enrollment (range 0.1-7.3 yrs).	21	Pilot case study; MoodGym training program (5 weekly sessions - Web exercises)	CES-D, PHQ-9	▲CES-D: p<0.05, ▲PHQ-9: p<0.05	IV

Legend: ▲, significant improvement compared to control group/baseline; ■, no significant difference compared to control group/baseline.

Abbreviations: AI, 10-item Anxiety Inventory; BRIEF GEC, Behavior Rating Inventory of Executive Function Global Executive Composite; BRIEF, Behavior Rating Inventory of Executive Function; BSI, Brief Symptom Inventory; BSI-D, Brief Symptom Inventory-Depression subscale; CBCL, Child Behavior Checklist; CBQ, Conflict Behaviour Questionnaire; CDI, Children's Depression Inventory; CES-D, Center for Epidemiologic Studies Depression Scale; CIQ, Community Integration Questionnaire; DRS, Disability Rating Scale; EuroQol, Quality of Life Measure; FAD, Family Assessment Device; FBII, Family Burden of Injury Interview; FIM, Functional Independence Measure; FPS, Family Problem Solving; FSE, Functional Status Examination; GOS-E, Glasgow Outcome Scale-Extended; GSI, Global Severity Index; HCSBS-AB, Home and Community Social Behavior Scale-Antisocial Behavior; MHI-5, Mental Health Index-5; NFI, Neurobehavioral Functioning Inventory; NFI-D, Neurobehavioral Functioning Inventory-Depression subscale; PHQ, Patient Health Questionnaire; PHQ-9, Patient Health Questionnaire for depression; PQOL, Modified Perceived Quality of Life; PSI, Parenting Stress Inventory; SCL-90 GSI, Global Severity Index of the Symptom Checklist-90; SCL-90-R, Symptom Checklist-90-Revised; SCL-GSI, Global Severity Index - Global Psychological Symptoms; SES, The Hauser-Warren Socioeconomic Index; SF-12, Short Form Health Survey-12; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; SPSI-short version, Social Problem-Solving Index;

Table 2. Overview of efficacy studies for technology-based approaches and mental health outcomes for the TBI patient population.

In a follow up study, Bell and colleagues examined the effectiveness of scheduled telephone counseling on clinical symptoms and general health, including mental health, in 336 patients with mild TBI (the preceding study population consisted of patients with moderate to severe TBI (Bell et al., 2008)). Participants were recruited within three months of their TBI and the assessments were performed at six months post-injury. As in the preceding study, the researchers implemented a two-group parallel randomized clinical trial, utilizing motivational interviewing techniques in the conduct of the telephone counseling and educational intervention, and contacted the participants at 2 days and 2, 4, 8 and 12 weeks post-discharge from the emergency department where they were recruited. The researchers reported improvements in clinical post-traumatic symptoms but not the composite variable reflecting mental health in the intervention group. The authors commented on this unexpected outcome by highlighting the fact that the intervention specifically targeted symptom management. The secondary mental health outcomes were unaffected by the utilization of the telephone medium.

Bell et al.'s work represents the first large randomized intervention studies that allowed for sound scientific and generalizable results for a TBI population. The initial studies revealed that telephone-based interventions are an effective tool in ameliorating depressive symptoms. These positive outcomes could be attributed to targeted training of the caregivers in the intervention group which enhanced implementation of the recommendations provided as part of the standard of outpatient care. It also provided the matching of the intervention to individual needs in timing and content. The follow-up post-TBI symptom-focused study did not find a positive mental health outcome, but reported improved symptomatology. The differing outcomes highlight the critical role that the focus of the intervention plays, regardless of the medium. The studies also demonstrate that telephone technology is effective in delivering various types of interventions for the TBI population. Further research is required to evaluate optimal timing and frequency of the contacts, as well as cost-efficacy analyses of telephone-based follow-ups of patients post-TBI.

Online Family Problem Solving program. Wade and colleagues developed the *Family Problem Solving* (FPS) online treatment program for families of children with TBI (Wade et al., 2005; Wade et al., 2006). The original program, which was designed to be used by members of the family together, was comprised of a homepage with links to announcements, contact information, resources and the session materials. The program offered twelve sessions including eight "core" sessions teaching skills related to problem-solving, communication, and TBI specific behaviour management, and four sessions addressing stressors and burdens including stress management, working with the school, sibling concerns, and marital communication. The interactive sessions were completed by the families in advance of a videoconference with a trained therapist who reviewed the completed exercises and implemented a problem-solving process to address a problem or goal identified by the family. Validated quantitative pre- and post-outcome measures were completed aimed at assessing parental stress and burden, distress, depression, anxiety, as well as child behaviours and depression.

In the pilot evaluation study, a convenience sample of six families was recruited to assess the efficacy of the intervention (Wade et al., 2005). All families successfully completed the program with 10.3 (range 7-12) and 10.1 (range 7-14) web sessions and videoconferences completed, respectively. Even with the small sample size significant improvements were observed from pre- to post-intervention on parental adjustment (injury related stress and burden, parenting stress, depression, global psychological symptoms) and child adjustment (antisocial behaviour). There were no significant differences in self-reported depressive symptoms of the injured child. The authors identified the small sample size, lack of a control group, and potential bias by social desirability factors (participants were given the computer to keep after study completion) as limitations in their study. Nevertheless, the findings suggested that a computer-based intervention might successfully be used to improve both parent and child outcomes following TBI in children. This study contributed to the early work in this area by expanding the spectrum of technological solutions explored for treating mental health in the TBI population to include online interventions.

To address some of the limitations of their pilot study Wade and colleagues conducted a larger randomized clinical trial to evaluate the efficacy of the FPS intervention on parental anxiety, depression, and psychological outcomes, following pediatric TBI (Wade et al., 2006). Eligible families (child 5-16 years of age who had sustained a moderate-to-severe TBI between 1 and 24 months previously) were randomly assigned to the FPS group (n=26) or an Internet resources comparison (IRC) group (n=20). In addition to usual psychosocial care,

all participating families received a computer (which they were allowed to keep at the end of the study), printer, high-speed Internet access, and a home page with links to brain injury web sites. Families in the FPS group also received a web camera for the duration of the study. Two additional supplemental sessions were added to the FPS website from the pilot study: anger management and pain management.

Baseline demographic and injury characteristics did not differ between the two groups. Attrition was 12% in the FPS group versus 0% in the IRC group (not significant). After controlling for baseline symptom levels, parents in the FPS group reported significantly less depression, anxiety, and general psychiatric symptoms as compared to those in the IRC group. The study, the first randomized controlled trial to combine a web-based intervention and synchronous videoconferencing with a trained therapist, also demonstrated that neither demographic nor injury characteristics moderated the treatment response. This suggested that even parents of lower socioeconomic status, or families with children of any age, injury severity, or time since injury could benefit from an online skill-building intervention. The main limitations of the study were a relatively small sample size that was skewed towards less severe injuries, the reliance on self-report measures, and the lack of an extended follow-up period. Moreover, based on the study design it was not possible to disentangle whether the treatment effect was a result of the problem solving intervention, or having access to a trained therapist, or both. An additional study with an attention control would be required to address this limitation.

Teen Online Problem Solving intervention. Wade and colleagues subsequently expanded their program to create modules aimed at adolescents (Wade et al., 2008). The Teen Online Problem Solving Intervention (TOPS intervention) emphasized the development and/or remediation of primary executive function skills (e.g. self-awareness, self-regulation, planning, and problem solving) and training in language pragmatics and social information processing to improve social competencies. The TOPS intervention was comprised of ten core sessions and six supplemental sessions including the four sessions from the original program plus “planning for high school” and “talking with your adolescent”. Participants were randomized to audio or no-audio versions of the online components.

Children 11 to 18 years of age who had sustained a moderate-to-severe TBI in the previous 24 months were eligible to participate. Nine out of 17 eligible families (53%) agreed to participate. All nine families completed the ten core sessions with six completing one or more supplemental session. Significant improvements were reported on child internalizing symptoms and self-reported depression as well as parental depression. Moreover, significant reductions in parent-adolescent conflicts, number of problem issues, and severity of the family’s problems were observed. There were no differences in outcomes between the audio versus non-audio groups.

The authors proposed that the cognitive reframing and problem solving skills developed through the TOPS intervention enabled parents and adolescents to resolve issues that otherwise could have contributed to anxiety and depression. They also discussed several benefits of technology-based approaches to treatment: information can be provided in a variety of modalities and may be more cost-effective than traditional approaches. Similar limitations were cited to those of their previous work, including a small sample size, lack of control group, reliance on self-report measures, and inability to disentangle the most effective component of the intervention. In addition, the need for longer-term follow up to ascertain maintenance of gains, was noted.

Online cognitive behaviour training program - MoodGym. Topolovec-Vranic et al. recruited 21 patients with mild or moderate TBI to evaluate the acceptability and efficacy of the Internet-based MoodGym training program (<http://moodgym.anu.edu.au>; Topolovec-Vranic et al., 2010). The MoodGym program was developed at the Australian National University to treat and prevent depression in a community-based population, primarily youth. The program consists of five cognitive behaviour training modules, a personal workbook, an interactive game, and a feedback evaluation form. Of the 21 patients who consented to participate in the study, 16 completed at least one module and 13 completed all of the modules. Using an intention-to-treat analysis, scores on the Center for Epidemiological Studies-Depression Scale (CES-D) were shown to decrease by 1.03 points for each module of the workshop completed. Significant decreases from baseline on both the CES-D and the Patient Health Questionnaire-9 (PHQ-9) were found at the 12-month follow-up assessment.

Although preliminary efficacy of the MoodGym training program was demonstrated for patients with TBI and symptoms of depression, this study was limited by its small sample size, lack of control group, and low completion rates for the intervention. While many participants commented that the program was enjoyable and that they would recommend it to others, some participants identified challenges such as concentration and memory challenges, and understanding some of the content on the website. A customized program addressing the cognitive deficits experienced by some patients with TBI may be more appropriate for this population.

3.3 Concluding remarks on the literature review

The scoping literature review of technology-based treatment programs for patients with TBI and/or their caregivers revealed limited scientific data to date. Only four treatment programs were identified that were evaluated with a TBI population (see Table 3). These four programs were presented in five feasibility studies, and seven evaluation studies which utilized a mental health outcome measure. Six of the seven efficacy studies demonstrated significant improvements in at least one of these measures for the patient or their caregiver. Depression was the primary mental health related outcome assessed.

Technology	Description	Audience	Study Authors
Telephone intervention	Teletherapy through motivational interviewing, counselling and education.	Individuals with TBI	Bell et al. 2005, 2008; Bombardier et al. 2009
Family Problem Solving (FPS) online treatment program	Website designed for families of children who had TBI. Several different modules on the website aim at helping families cope with a child who is recovering from a TBI.	Families with a child who sustained a TBI	Wade et al. 2005, 2006
Teen Online Problem Solving (TOPS) Intervention	Website designed for families with an adolescent who sustained a TBI. Similar to FPS but geared towards issues pertinent to teenagers.	Families with an adolescent who sustained a TBI	Wade et al. 2008, 2009
MoodGym training program	Website designed to help treat depression in the youth population, using cognitive behavioural training modules, interactive games and a feedback evaluation form.	Individuals with TBI	Topolovec-Vranic et al. 2010

Table 3. Overview of technologies evaluated for the treatment of mental health conditions for TBI patients and caregivers.

Given the limited work in this area there is a need for further studies to establish the types of technologies and treatments that are effective for this population. Much of the work reported is characterized by small sample sizes, feasibility studies, unclear differentiation of the effect of the treatment medium versus the actual therapeutic technique utilized, and lack of ethnic or geographic diversity. There is little information to identify which patients with TBI are most likely to adopt and adhere to various technology-based treatment approaches. No cost-efficacy data are available and few studies describe the practical limitations of using such approaches (e.g. stress placed on families as a result of technical difficulties or lost Internet connectivity; lack of personal contact; constant upgrading and maintenance of the technologies and equipment).

Even with these potential barriers, the recent widespread adoption of various computers and handheld devices in everyday life activities presents an opportunity to examine how these technologies can best facilitate various types of mental health treatments customized for the TBI population. While the studies reviewed in this section identified some promising programs delivered by telephone or internet, there are great opportunities for leveraging up and coming technologies such as handheld devices and virtual reality. In an effort to motivate a systematic approach to the study of different types of technologies, the next section of this chapter will present the results of a survey that investigated patients' attitudes towards and willingness to use various technologies as part of their mental health treatment post-TBI.

4. Survey: attitudes towards technology-based approaches to mental health care in a traumatic brain injury population

The literature review described in the preceding section of this chapter has identified several technology-based treatment programs which have been evaluated for patients with TBI. While the technological provision of mental health services may be well suited for these patients, no studies have specifically addressed this question. The purpose of the following study was to examine, using a survey-based approach, the knowledge and attitudes of patients with mild or moderate TBI towards using technology to access mental health care. A better understanding of patients' experience with the use of technologies and their attitudes towards using such technologies for treatment may aid in the development of more tailored and useful interventions in the future.

4.1 Methods used for the survey

A convenience sample of all patients attending an out-patient Head Injury Clinic in Toronto, Canada, specializing in mild to moderate TBI, were recruited to participate in the study. Patients were invited by a research assistant to complete the "Technology Access and Knowledge Survey", adapted from a previous survey (Wilson et al., 2008) while they waited to be seen by the Clinic physicians. The adapted survey captured:

- basic demographic information about the patient (age, gender, education level, marital status, current employment status);
- information related to the injury (time since injury, mechanism of injury, any intracranial computed tomography diagnoses);
- data regarding the respondent's use of computers and the Internet, their knowledge and comfort with various technologies (e.g. chat room, online banking, personal

electronic device, virtual reality, mp3 player), and their comfort with using a computer or computer program to receive personal mental health information/treatment. Study participants also completed the PHQ-9, a nine-item depression module taken from the PHQ (a screening tool for mental health diagnoses used in the primary care setting). The PHQ-9 has been demonstrated in the primary care setting to be sensitive to both diagnosis of depression according to the DSM-IV criteria and to measurement in depressive symptom severity (Nease, Jr. & Maloin, 2003). It has also been demonstrated to be sensitive in screening for depression in TBI patients (Fann et al., 2005). Scores from the PHQ-9 range from 0-27 with a sum score of 12 or above being the best screening criterion for major depression in this population (Fann et al., 2005). Some participants did not complete all of the questions on the survey. The number of participants completing each question is indicated in the tables. This study was reviewed by the Research Ethics Board of the participating institution and informed consent was obtained from all participants.

4.2 Results of the survey

4.2.1 Description of the study sample

Study participants. A total of 422 of 520 patients who were approached (81% response rate) consented to participate in the study between May 2010 and June 2011. The average age of participants was 42 years (range 17-86 years) and 59% were male. The majority of the participants had completed some college, were never married or married/common-law, and were employed full-time. Detailed demographic characteristics of the study participants are provided in Table 4.

Characteristic	Responses
Gender (N=378)	
Male	223 (59%)
Education Completed (N=390)	
Grade School	66 (17%)
High School	79 (20%)
Some College/Trade School	125 (32%)
Undergraduate Degree	83 (21%)
Postgraduate Degree	36 (9%)
Marital Status (N=384)	
Never Married	158 (41%)
Married/Common Law	158 (41%)
Separated/Divorced	58 (15%)
Widowed	12 (3%)
Employment Status (N=398)	
Student	40 (10%)
Unemployed	82 (21%)
Employed	131 (33%)
Retired	36 (9%)
Other	107 (27%)

Table 4. Demographic characteristics of study participants.

Injury characteristics. The average time since injury for the patient sample was 17 months (range 0-166 months). The main mechanism for the injury was a motor vehicle collision. Most participants reported a loss of consciousness following the injury and having had a computed tomography (CT) scan completed with one third reporting that abnormalities were observed on the scan. Detailed injury characteristics of the study participants are provided in Table 5.

Characteristic	Responses
Mechanism of Injury (N=406)	
Motor Vehicle Collision	204 (50%)
Bicycle	17 (4%)
Violence	23 (6%)
Fall or hit by object	101 (25%)
Pedestrian	26 (6%)
Suicide attempt	1 (0.2%)
Work-related	19 (5%)
Sports	15 (4%)
Loss of consciousness (N=375)	
None reported	53 (14%)
Less than 30 minutes	160 (43%)
More than 30 minutes	83 (22%)
Unknown	79 (21%)
CT Scan Results (N=371)	
Positive	130 (35%)
Negative	120 (32%)
Not done	32 (9%)
Unknown	89 (24%)

Table 5. Injury characteristics of study participants.

Mental health status. The average PHQ-9 depression score for all respondents was 11.4 (median = 12). A score of 12 or above is considered an indication for major depression in this population. In our sample, half of the respondents scored at 12 or above (51%) indicating major depression. Forty two percent of respondents indicated that they were receiving treatment for a mental health condition at the time of survey completion.

4.2.2 Experience with computers

Access to computers and the Internet. Only 8% of the survey respondents did not have a computer at home. Eighty one percent indicated that they accessed the Internet at least one time per day. While at home, most individuals reported spending significant time on the computer and Internet: more than 4 hours per day (13% on the computer and 11% on the Internet), 1-4hours per day (36% and 35%), or less than 1 hour per day (32% and 35%). In addition to using a computer at home, over half of the respondents also had access to a computer (62%) and/or the Internet (58%) at work.

Specific experiences with using the Internet. More than half of respondents had *extensive experience* (i.e. "have done it many times") using the Internet for email (77%), online banking (52%), and downloading files (60%). However, less than half of participants (42%) had similar experience using handheld devices for various purposes – *extensive experience* with handhelds for accessing the Internet was reported by 43% of respondents, for downloading

files by 33%, and for watching videos by 33%. Based on their experience with using the Internet in general, the majority of respondents (61%) felt that even with precautions (e.g. encryption, password protection, etc.) their information online was not private.

4.2.3 Attitudes towards web-based approaches to mental health

Despite their belief that information online is not completely private even with precautions, most respondents (63%) reported that they would be willing to enter personal mental health information online (e.g. age, gender, medical history, completing questionnaires).

Attitudes towards using a computer for mental health programs. An overwhelming proportion of the respondents (82%) endorsed that they would use a *computer/computer program* as an aid to their mental health care if it were available. When broken down into various components, approximately half of the survey respondents felt very comfortable using the computer for various mental-health related purposes: to access specific mental health information (48%), to complete exercises as an aid to their regular mental health treatment (55%), to receive personal feedback on exercises (50%), and to receive personal feedback from a counselor (52%). A significant proportion of respondents also indicated that they felt comfortable using a computer to complete exercises as their *main* form of mental health treatment (39%).

Attitudes towards using a handheld device for mental health programs. Although not as high as for computer-based programs, a significant proportion of respondents (65%) reported that they would be willing to use their handheld device as an aide to mental health care if it were available. Specifically, 36% indicated they would use their handheld device to access specific mental health information, 35% to complete exercises as an aid to their regular mental health treatment, 37% to receive personal feedback on exercises, and 39% to receive personal feedback from a counselor. In addition, 27% of the respondents felt comfortable using a handheld to complete exercises as their *main* form of mental health treatment.

Types of online mental-health related activities of interest. Participants were asked to indicate their preferred mode of communication with a counselor. The largest proportion (85%) indicated *in person* as a preferred option, followed by *over the phone* (52%), via *email* (40%), via *teleconference* (31%), and via *chat* (30%). A considerable portion of the patients in this survey also indicated that they would be willing to access mental health information online (56%), they would install a treatment program on their home computer (51%), and they would log into a secure Internet treatment program (46%). A smaller segment of the sample reported that they would use a virtual reality treatment program (40%) or that they would be willing to respond to anonymous mental health questions on the Internet (39%).

4.3 Concluding remarks on the survey findings

This survey of 422 patients with mild to moderate TBI revealed that half of the individuals (51%) in this sample met the screening criteria for major depression (PHQ-9 greater than or equal to 12) and 42% were currently receiving treatment for a mental health condition. A large proportion of the respondents (82%) indicated that they were interested in receiving further mental health treatment with the help of technological solutions. This result implies that there is a need in this patient population for additional mental health care that could be made accessible through the use of various technologies.

The majority of the patients surveyed owned a computer and had Internet access at their home (92%), while some also used a computer and the Internet at their workplace (62% and 58% respectively). Most of the respondents reported significant experience with the use of a computer and the Internet for various purposes, such as email (77%), banking (52%), downloading files (60%). A relatively smaller proportion reported extensive experience with the use of handheld devices for accessing the Internet (43%), downloading files (33%) or watching videos (33%). Overall, approximately 80% reported having extensive experience using a computer, while only 42% reported such experience using handheld devices. However, given the rapid changes in the field and that more and more individuals are acquiring handheld devices such as smart-phones, we anticipate that this proportion will significantly increase over time.

Even if they indicated a willingness to use a computer or a handheld device, patients seemed reluctant to use technology-based treatments as their main or only treatment. They were, however, very interested in utilizing technology-based interventions as an aid to traditional mental health treatment. While patients indicated that their preferred way of speaking to a counselor was in person, many were also willing to utilize the telephone, email, chat, computer and the Internet to connect to a counselor. They were also open to installing treatment programs on their home computer or using secure website treatment programs.

The findings of this survey highlight the importance of patient preferences in selecting a treatment for post-TBI depression. While previous research has reported the significance of TBI patient preferences for treatment modalities such as physical exercise, counseling, antidepressants, and others (Fann et al., 2009), the present study clarifies the extent of patients' willingness to utilize a variety of different technological solutions in their mental health treatment, reveals patient preferences to that effect as well as barriers to adoption that need to be considered. The survey did not ask patients to indicate their relative acceptance of technology-based approaches to mental health treatment as compared to pharmacological or alternative treatment options. This would be an interesting and important question for the future. Moreover, the survey did not discern whether respondents were being treated for a pre- or post-injury mental health condition. Pre-injury psychiatric disorder has been shown as a predictor of post-injury disorders (Gould et al., 2011) and these individuals may have different needs and preferences from patients with new-onset mental illness post-injury.

The results of the present survey are aligned with previous reports from the broader acquired brain injury literature: patients expressed strong interest in using telerehabilitative services to assist with problems in memory, attention, problem-solving, and others (Ricker et al., 2002). These studies collectively demonstrate that there is a need and demand for future work in this area.

5. Discussion

This chapter reviewed the current state of science regarding technology-based approaches for mental health care for people who have experienced a TBI. The literature review revealed that work in this area is at initial stages. Many of the reports fall within the scope of feasibility and pilot studies and do not offer scientific validation of the effectiveness of using technology with respect to mental health outcomes (only three papers received an AAN level I rating and two of these papers were based on the same study) . The scoping review identified a total of seven studies that utilized a scientific approach towards the evaluation

of efficacy. These studies, however, presented unclear differentiation of the effect of the treatment medium versus the actual therapeutic technique utilized. In addition, three of the studies were characterized by small sample sizes ($N < 25$ participants). Thus, there is a need for future work to further corroborate the existing evidence on the utility of technology-based approaches for the treatment of mental health conditions in the TBI population. Future comparative studies are needed to address some of the gaps related to technology implementation: which technologies are most effective; what is the optimal coupling between a particular type of mental health treatment (e.g. cognitive behaviour therapy) and a particular type of technology (e.g. teletherapy); what are the costs associated with the development and delivery of such resources; and what are the potential barriers to adoption by this particular population (social, physical, economical, etc.).

The technology access and attitudes survey highlighted that patients with TBI are a receptive audience for the implementation of technological solutions to help their mental health care with 82% of the participants expressing a willingness to do so. It is important to note that the sample studied was predominantly patients with mild, and some moderate TBI. The results from this sample are not necessarily translatable to a population of patients with severe TBI who have greater cognitive deficits. Moreover, the patients sampled in the study were those presenting to an out-patient Head Injury Clinic with persisting post-concussive symptoms (on average 17 months post-injury). This could represent a group that is highly invested in alternative treatment options, and more willing to utilize such approaches than individuals in the acute and sub-acute stages post-injury. On the other hand, the participants in this study may be less interested in using technology-based approaches as they have persisting medical concerns to deal with, and may be skeptical of new treatment options after years of trying to manage their symptoms. Additionally, all participants were recruited from a single centre and may not accurately represent the general TBI population.

The survey identified several specific issues to be considered in the design of technology-based solutions for mental health care for the patient with TBI:

- Since only 63% of patients stated that they would enter personal health information online, having a guest/anonymous option on websites would allow for a wider reach within this population. Websites should clearly describe the safety and protection of the users' privacy and the limitations to such.
- Most respondents indicated a preference for access to a counselor and would primarily be willing to use technology-based approaches as an adjunct to traditional therapy. However, a solid proportion of patients also indicated that they would use such resources as their main form of mental health treatment (39% would use a computer and 27% would use a handheld). Understanding the patient's preferences and providing access to face-to-face resources if needed is critical especially given the preliminary and relatively scarce data available to support the efficacy of stand-alone technology-based programs. There is an inherent risk in relying upon technology-mediated interventions in that patients may feel that self-management alone is sufficient when they need specialized treatment.
- The safety considerations for those who are severely depressed or suicidal must be recognized as there is a lack of monitoring of the individual when they access online resources, while a healthcare provider would be able to identify risk factors and intervene if necessary.

- Patients' responses also indicated a preference towards using computers compared to handheld devices for their online mental health treatment. While the survey did not directly identify the underlying reason for this preference, it is likely that lack of exposure to or experience with handheld devices is a barrier to adoption potential – the survey found a considerable difference in experience with using computers (80%) versus handheld devices (42%). We anticipate with the rapid uptake of handheld devices in the consumer market, the latter number will steadily rise in the coming years. Thus researchers and developers should strongly consider designing treatment programs that will be accessible on such devices.
- The results from some of the studies reviewed suggest that programs should be tailored for this patient population to take into consideration the cognitive, somatic, and affective deficits they may be experiencing (e.g. poor memory, difficulty with concentration, vision disturbances, apathy). Modularizing exercises into smaller components is one way to address this problem. Further, in addition to video, audio components may allow for better assimilation and internalization of intervention materials by helping to alleviate problems with concentration (Wade et al., 2006).

6. Conclusion

The recent widespread adoption of various computers and handheld devices in everyday life activities presents an opportunity to examine how these technologies can best facilitate various types of mental health treatments for individual with TBI. The results of the survey presented in this chapter indicate that patients are willing and enthusiastic about using such approaches to aid in their mental health care. While there is limited research to date in this field, the innovative studies available suggest that technology-based approaches are feasible, acceptable, and effective in improving mental health outcomes of patients with TBI and their caregivers. In this chapter we have also aimed to identify some points of consideration during the development of technology-based treatment programs for patients with TBI. Overall, the potential benefits of technological approaches to mental health care in this patient population are numerous and deserve further research attention and efforts.

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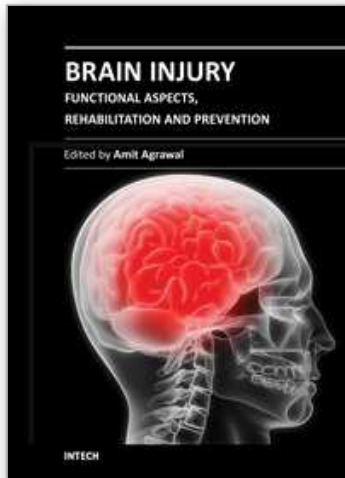
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The present two volume book "Brain Injury" is distinctive in its presentation and includes a wealth of updated information on many aspects in the field of brain injury. The Book is devoted to the pathogenesis of brain injury, concepts in cerebral blood flow and metabolism, investigative approaches and monitoring of brain injured, different protective mechanisms and recovery and management approach to these individuals, functional and endocrine aspects of brain injuries, approaches to rehabilitation of brain injured and preventive aspects of traumatic brain injuries. The collective contribution from experts in brain injury research area would be successfully conveyed to the readers and readers will find this book to be a valuable guide to further develop their understanding about brain injury.

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