TBM

SYSTEMATIC REVIEWS

Meeting them where they are: Using the Internet to deliver behavioral medicine interventions for pain

Christine Rini, PhD[1,2] David A. Williams, PhD[3] Joan E. Broderick, PhD[4] Francis J. Keefe, PhD[5]

[1]Gillings School of Global Public Health,
University of North Carolina, Chapel Hill, NC, USA

[2]UNC Lineberger Comprehensive Cancer Center,
University of North Carolina, Chapel Hill, NC, USA

[3]Chronic Pain and Fatigue Research Center,
University of Michigan, Ann Arbor, MI, USA

[4]Department of Psychiatry and Behavioral Science, Putnam Hall,
Stony Brook University, Stony Brook, NY, USA

[5]Pain Prevention and Treatment Research Program, Department of Psychiatry and Behavioral Sciences,
Duke University Medical Center, Durham, NC, USA

Correspondence to: C Rini
christine.rini@unc.edu

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Abstract

Pharmacological and interventional pain medicine treatments are emphasized in the routine treatment of chronic pain despite strong evidence for the efficacy and safety of behavioral approaches. Most medical professionals have not incorporated behavioral pain treatments into their practices. Internet-based interventions have the potential to increase clinical use of these treatments. We discuss the strengths and weaknesses of current Internet-based behavioral pain management interventions, focusing on three broad intervention categories: therapist-guided interventions, unguided (automated) interventions, and pain-relevant applications for mobile platforms. Examples of each category are discussed, revealing a high degree of variation in approaches, user interfaces, and components as well as variability in the degree to which these interventions have been subjected to empirical testing. Finally, we highlight key issues for research and clinical implementation, with the goal of advancing this field so that it can meet its potential to increase access to evidence-based behavioral medicine treatments for chronic pain.

Keywords

Chronic pain, Internet-based interventions, Behavioral medicine, Cognitive-behavioral therapy, eHealth, mHealth

Implications

Practice: Internet-based behavioral medicine interventions for managing chronic pain have the potential to increase access to behavioral pain treatments, which have been underused in routine treatment of chronic pain despite strong evidence for their efficacy and safety.

Policy: Although promising, funding and policy attention to research and systemic barriers related to the design, implementation, and evaluation of Internet-based behavioral pain interventions must be addressed if these approaches are to play a significant role in increasing access to the evidence-based treatments on which they are based.

Research: There is a pressing need for rigorous and methodologically sophisticated clinical trials that compare the efficacy of Internet-based behavioral pain interventions to other credible interventions; research to guide intervention development and clinical implementation of these interventions is also needed.

Chronic pain is a growing problem affecting 30.7% of the US population [1] with estimated costs to the US economy exceeding $61.2 billion [2]. Pharmacological and interventional pain medicine treatments are emphasized in the treatment of chronic pain even though benefits from these approaches tend to be modest for most patients [3–5]. In contrast, behavioral approaches to chronic pain management possess good evidence for efficacy, lack many of the side effects of medications, and produce effect sizes that rival or surpass those of pharmacological agents for many chronic pain conditions [5, 6]. Protocols based on behavioral and cognitive-behavioral theories of pain have been used to reduce pain, psychological distress, and physical disability among patients with conditions such as low back pain [6, 7], fibromyalgia [8, 9], arthritis [10, 11], cancer [12, 13], complex regional pain syndrome [14], headache [15], and chronic pelvic pain [16]. Other behavioral approaches to managing chronic pain also show promise, including affectively oriented approaches such as mindfulness or acceptance therapy [17] and interventions that incorporate positive health principles to enhance motivation, psychological resilience, and well-being [18].

Despite a strong evidence base, most medical professionals have not consistently incorporated behavioral medicine into their practices. Barriers include lack of training in and familiarity with these interventions, difficulties identifying clinicians qualified to deliver them, travel requirements for patients (because many of these interventions involve in-person meetings), and reimbursement difficulties [19–23]. Especially in light of the increasing prevalence of chronic pain as the US population ages [24, 25], it is important to find ways to overcome barriers that limit the use of these empirically supported interventions.

One strategy for achieving this goal involves using the Internet to "meet patients where they are," delivering evidence-based behavioral medicine pain treatments to them in a way that meets their needs while being affordable and convenient. Indeed, the Internet is emerging as a valuable

resource for delivering behavioral medicine interventions for various physical and mental health problems [e.g., 26–29]. An increasing number of randomized trials demonstrate that "eHealth" interventions delivering evidence-based treatments through web sites, e-mail, and mobile technologies can improve symptom management, psychological well-being, and lifestyle behaviors compared to control conditions. The effects of these interventions can be comparable to effects attained by more traditional face-to-face interventions [30–33]. Although this literature is still evolving, recent reviews support the utility of using the Internet as a means of delivering behaviorally based interventions for pain [34, 35].

Moreover, Internet-based interventions are acceptable to many patients. A recent study of primary care patients [36] found widespread interest in Internet-based treatments: 49% of patients said they would consider using them. Although a larger percentage of patients reported interest in in-person therapies (91%), acceptance of technology-based approaches is likely to grow over time as potential users become increasingly likely to use the Internet, computers, smart phones, and other technologies [37, 38].

An important benefit of delivering behavioral medicine pain treatments via the Internet is that patients can use the programs at their own pace with access unlimited by time, day, location, and availability of therapists or educators. Furthermore, these interventions can be structured to deliver evidence-based resources in a consistent but personalized form, augmenting limited healthcare resources [39]. They also have the potential to allow clinicians to reach larger segments of the population [40] including hard-to-reach patients such as those who live in remote areas or those who are socially withdrawn, physically disabled, economically disadvantaged, without transportation, or concerned about treatment-related stigma [41, 42]. Well-designed Internet-based behavioral treatments can be safe and cost-effective to disseminate [43]. Thus, using the Internet to deliver behavioral medicine interventions for chronic pain has the potential to overcome barriers that limit use of in-person therapies.

Other benefits may arise with the emergence of increasingly sophisticated technologies for sharing and using information. Integrating Internet-based interventions with the "meaningful use" [44] of electronic medical records (EMRs) holds particular promise. For instance, patient-reported pain and other symptoms assessed in an Internet-based intervention can be delivered to EMRs to facilitate multi-modal assessment of chronic pain, engage patients more fully in their care, and enhance cross-communication and coordination of care. However, a recent study highlights the need to ensure that both patients and providers accept these types of systems. The study, which investigated an Internet-based program to facilitate shared decision making for prevention of cardiovascular disease, revealed that primary care providers often did not use the patient-reported data made available to them [45].

In sum, there are compelling reasons to increase use of behavioral medicine treatments in clinical pain care, and additional reasons to consider delivering them via the Internet. Below we review existing and emerging approaches for using the Internet to deliver behavioral medicine interventions for chronic pain, including comprehensive therapist-guided and unguided (automated) programs as well as more targeted applications delivered on mobile platforms. After describing an example of each type of intervention and discussing their strengths and weaknesses, we provide a broad overview of key issues for research and clinical implementation, with the goal of advancing this field so that it can meet its potential to increase access to evidence-based behavioral medicine treatments for chronic pain.

TYPES OF INTERNET-BASED INTERVENTIONS

Internet-based behavioral pain management interventions can be classified into three types: (1) comprehensive programs guided by a professional therapist or other trained provider, (2) unguided or automated programs that do not include contact with a therapist, and (3) pain applications ("apps") that provide targeted pain self-management tools specifically designed for mobile platforms (and typically not specifically incorporating therapist guidance). The next section will briefly discuss each type, focusing on adult populations. Without specific examples, it can be difficult to know how Internet-based interventions accomplish their educational and therapeutic goals. Therefore, rather than summarizing general characteristics of all available interventions within each intervention type, we instead discuss several programs that illustrate key features of each type of intervention.

As will be clear from the examples, the interventions vary in terms of their approaches, user interfaces, components, and evidence of treatment efficacy. Perhaps because provision of information is a strength of the Internet, many are information-focused. In general, however, purely information-focused interventions will not be as effective at promoting lasting behavior change as interventions that incorporate behavior change techniques such as self-monitoring, skill training, observational learning or modeling (e.g., with videos showing others using skills) [46, 47], and interactive exercises that promote mastery and maintenance of behavior change. Developing a program that incorporates these techniques is more challenging than developing a program focused on delivering information. In-person therapeutic activities are highly interactive, and some aspects of the therapeutic context are subtle and difficult to simulate online. For instance, a patient having difficulty using relaxation techniques may grimace and shift uncomfortably but not report having problems. These behaviors will be obvious in a face-to-face session but only measurable online with well-designed questions and feedback.

As will also be clear, empirical tests of interventions are often absent, and when done they vary in their methodological quality and rigor. Some of these issues are discussed in two recent systematic reviews of the efficacy of Internet-based behavioral pain management interventions [34, 35]. In the descriptions that follow, we will highlight strengths and weaknesses of intervention designs and evaluation.

Guided programs

One approach to delivering eHealth interventions combines technology with the active involvement of a professional who interacts with individuals completing the program. The backgrounds of these professionals vary from clinical psychologists with extensive training and experience delivering behavioral interventions to trainees (e.g., a postdoctoral fellow or graduate student) or laypeople. We refer to them as "therapists" for brevity. In these programs, therapists may deliver much of the behavioral intervention, but more typically their activities complement Internet-based multi-media training in pain management. For instance, therapists may help program "users" learn to apply new skills to their daily life, assist in problem solving, deliver motivational messages or encouragement, provide feedback, or follow-up on users to maximize adherence. Thus, this type of intervention may be considered to be "minimal contact" because much of the online content and eHealth resources replace what therapists traditionally provided during face-to-face interventions. Communications between the therapist and users may be asynchronous (e.g., through emails or "threaded" bulletin boards) or synchronous (e.g., in a "chat room").

An early example of a therapist-guided eHealth intervention was a Swedish program for low back pain patients [48]. The program website included six training modules designed to be completed over 6 weeks. Training was based on cognitive-behavioral treatment techniques (i.e., goal setting, relaxation, exercise and stretching, cognitive restructuring, activity pacing, and relapse prevention). Users completed pain diaries and had structured telephone calls with a therapist each week. Calls lasted about 10 min and involved reviewing homework, answering questions, and providing reminders and motivational messages. Additional email contact with therapists and technical support staff was available as needed. Therapists were trained graduate students supervised by a clinical psychologist and a physiotherapist with expertise in pain management.

A small (N=56) randomized controlled trial compared this program with a waitlist control. At the post-intervention assessment, the intervention group significantly improved in several aspects of pain coping (catastrophizing, control over pain, ability to decrease pain), but not on outcomes such as pain, pain interference, anxiety, or depression. By the 3-month follow-up, the waitlist control group had completed the intervention, so analyses examined change from pre-intervention to follow-up in the entire sample and found significant improvements in aspects of pain coping (praying and hoping, catastrophizing, control of pain, ability to decrease pain), perceived life control, punishing responses from significant others, pain-related attitudes, and depression. Besides lack of a real control group at follow-up, a limitation of the study is that it failed to compare the behavioral intervention to another intervention that controlled for therapist attention. Although the program appeared to have been well-accepted by users (e.g., there was minimal dropout), we note that all users had pre-existing Internet access and that recruitment methods (newspaper and online advertisements) probably ensured a motivated sample. More recently, a version of this intervention was tested in which telephone contact was replaced with email contact [49], and the researchers concluded that the two modes of communication worked equally well despite a failure to replicate effects of the intervention on perceived control over pain and ability to decrease pain.

Another example of a guided program is offered by the Expert Patients Programme (EPP) (https://selfmanage.org/BetterHealth/SignUp, http://www.expertpatients.co.uk/), a 6-week chronic disease self-management intervention [50] based on a face-to-face intervention developed by Lorig [51, 52]. It is relatively information-focused, providing extensive content in four parts. The first part, the *Learning Center*, offers interactive training in pain-relevant topics including individualized exercise programs, cognitive symptom management (e.g., relaxation, visualization, self-talk), negative emotion management, medications, physician–patient communication, healthy eating, fatigue management, action planning, and problem solving. The second part, the *Communication Center*, offers four interactive bulletin boards for discussion of action planning, problems, difficult emotions, and celebrations. Users join the program simultaneously in 20- to 30-person groups to help ensure the boards are populated. In addition to threaded (asynchronous) discussions begun in the boards, users' responses to exercises in the Learning Center are posted. A third part, *My Tools*, provides online tools for developing an action plan, an exercise log, and a medication log, plus access to audio relaxation exercises and links to health websites. The fourth part, a *Help* section, allows users to email trained peer moderators or program administrators (who can also be telephoned). Peer moderators are layperson tutors who have gone through the program and received 1 day of online moderator training. They use email to remind users to log in to the program, model action planning and problem solving, offer encouragement, and answer questions. They also post to the bulletin boards and monitor bulletin board content daily. Their role is to assist in tailoring and supporting users' interactions with the program.

EPP was tested in a non-randomized prospective longitudinal study of 568 people with chronic diseases (mostly arthritis) [50]. Assessments occurred at baseline and at 6- and 12-months post-treatment. The 12-month follow-up found significant improvement in pain, distress, communication with a physician, health-promoting behaviors (e.g., exercise), satisfaction with health care, and health care utilization. Users logged on to the program 40 times on average and completed 5.2 out of a possible 6 sessions; 79% completed all sessions. Bulletin board usage was high, averaging nearly 45 posts per participant. Cost savings were estimated to be 128 British pound sterling per participant based on observed reduction in health care usage for the intervention group versus controls and including fixed program development costs that would be reduced with wider dissemination. Although promising, the lack of a randomly assigned control condition limits conclusions that can be drawn with confidence.

A unique aspect of EPP (and other versions of it that address different patient populations and countries; [53–56]) is its use of trained laypeople or *peer moderators*. Because of their personal experience with a disease, peers are thought to be uniquely able to help users develop self-management skills and confidence in their ability to manage their disease. Studies of interventions using trained peers have yielded mixed results, and beneficial effects are often small in size [57, 58]. This research would benefit from greater reporting of details of peer activities and greater attention to best practices for training peers and appropriate roles for peers versus professionals [58]. Moreover, many of these studies have recruited samples consisting primarily of educated White women [57, 59], suggesting that this intervention format may be particularly appealing to that population. Nonetheless, we view this as a promising approach. Research is needed to evaluate the generalizability of the intervention to other populations [58, 59] and to identify subgroups most likely to benefit (e.g., those with low perceived control over their ability to manage their disease) [60].

Summary of guided programs

In addition to the programs described above, we identified 11 other guided programs that have targeted adults with pain, including headache pain [61–64], back pain [65–67], arthritis pain [54], mixed pain syndromes [68, 69], and self-reported chronic pain [70] [see [34,35] for systematic reviews of this literature]. Guided programs such as these exemplify the promise of using technology in conjunction with therapist contact to support user learning, behavior change, and motivation. Because the structure offered by this intervention format can help ensure that therapists adhere to treatment protocols [71], this approach may expand access to tested interventions, in part by eliminating barriers that limit many patients' ability to work with highly trained therapists (e.g., by allowing these therapists to work with a greater number of patients over a larger geographic area). Insofar as these programs require less therapist time, reach larger numbers of patients, eliminate the need for a meeting place, and reduce administrative costs, they should also be more cost-effective than in-person interventions [22]. Of course, a limiting factor is that patients must have the ability to use the programs (e.g., some degree of computer literacy) as well as access to the Internet and a computer or mobile device.

One issue that arises in guided interventions is the need for quality control. It is important to ensure that therapists have appropriate training, and their interactions with users should be monitored to ensure they are delivering treatment components in a competent manner that is consistent with the protocol. Drift from protocol is particularly likely with untrained or less experienced therapists and therapists whose ongoing efforts are not being monitored. Researchers should control and monitor the "dose" and content of therapist–participant interactions. If therapist behavior is unconstrained, the type and dose of therapist interaction will differ according to participant characteristics that are also likely to influence outcomes (e.g., pain severity, coping style, dispositional differences).

Surprisingly absent from this literature are studies examining effects of using Internet-based interventions to build upon treatment interventions offered by a therapist in face-to-face sessions. This approach could capitalize on already established relationships between therapists and patients and use information gathered in face-to-face sessions to improve methods for tailoring treatments to patient needs. In the field of mental health (e.g., cognitive-behavioral treatments for anxiety or depression) computer- or Internet-assisted programs have been used for tasks such as increasing and facilitating completion of homework, improving patient adherence and engagement, and facilitating delivery of treatment components such as exposure therapy [72, 73].

When a relationship between a patient and a therapist does not previously exist, the ideal amount of therapist availability is unknown and probably differs according to needs of users, who may have significant psychological and medical problems that are not easily initially detected or that arise during treatment. These types of problems are difficult to address remotely, particularly if users live in areas where access to providers is limited. Confidentiality issues arise when communicating via e-mail, and legal restrictions on practicing therapy across state lines may become problematic. These and other ethical and legal issues have been discussed in the literature [e.g., 74–77], but they are currently not well resolved.

In order to circumvent some of the problems and costs associated with including a therapist, some eHealth interventions are completely automated.

Although automated interventions are not appropriate as a sole intervention for every individual with pain, they do make standardized high quality behavioral medicine information about pain management accessible to populations of pain patients that might not otherwise be receiving this material. The next section reviews automated sites.

Unguided (automated) programs

Automated programs allow patient users to complete an intervention in a self-directed manner. With the exception that no therapist contact is used in this approach, much of the content is similar to guided interventions. In terms of function, instead of a therapist, unguided interventions may rely on tailored feedback, interactive problem solving, and automated remediation, reinforcement, and reminders (e.g., to practice skills or to complete additional program components). The training itself may be tailored to users' needs using their responses to questions, tests, or exercises.

One highly interactive program called painAction (http://www.painaction.com/Members/MyPage.aspx) targets people with chronic low back pain, combining educational content (divided into eight sessions) with multi-media and tailored feedback [78]. Developed with input from back pain patients, pain treatment clinicians, and back pain researchers, a unique feature of the program is that each session's content and activities are tailored to user characteristics with a "recommendation engine" (computer-implemented algorithms guided by user-reported data collected through online questionnaires). Users are instructed to review the tailored content delivered to them, and they are also allowed to explore the rest of site (a feature intended to simulate self-directed web "surfing"). Content covers topics often featured in cognitive behavioral treatment protocols such as managing thoughts and moods, goal setting, problem solving, relapse prevention, and activities to improve collaborative decision making, sleep, nutrition, stress management, and exercise. The program also includes interactive tools for symptom monitoring and use of skills, online assessments, and a library of articles.

A randomized controlled trial of 209 people with chronic low back pain compared the intervention condition (in which participants completed eight sessions in 4 weeks followed by five monthly booster sessions involving additional visits to the site) with a control condition (in which participants were provided with a standard text-based back pain management guide and asked to read it over 4 weeks). Intervention participants were asked to spend at least 20 min on the website for each session, and their website "dosage" was standardized by having them follow protocols that involved reviewing their tailored online content. Assessments were completed at baseline and at 1-, 3-, and 6-months post-baseline. Significant positive effects of the intervention were found for stress, use of several positive coping strategies, and global perceived improvement, but not for a number of other outcomes. However, intervention group participants recruited online (but not those recruited in pain clinics) reported significant improvements in worst and average pain and in use of coping self-statements compared with control group participants. The investigators noted that compared to people recruited online, pain clinic patients may have more complex or severe problems and may be less adept at using an Internet-based intervention. We note that this study used a more credible control condition than most studies and that the investigators used methods for controlling and tracking the intervention dose. Use of a relatively large sample is also a strength of the study.

Another automated program–Living Well with Fibromyalgia–was designed to provide behavioral treatment to rural communities in the northern midwest region of the USA [79]. It includes educational, exercise, and cognitive–behavioral treatment modules that provide information about fibromyalgia, symptom management (i.e., role of medications, exercise, sleep, relaxation, pleasant activities), and lifestyle adaptation (i.e., goal setting, problem solving, graded activation, reframing, communication). The site features multi-media streaming video lectures from experts on each topic, written summaries of lectures, downloadable worksheets, and audio files of relaxation exercises. Thus, it is highly patient-driven and focused on skills training.

To evaluate the efficacy of this website, a randomized controlled trial (N=118) of fibromyalgia patients referred by a physician compared 6 months exposure to this site to standard care. Patients randomized to the intervention arm were instructed to use the modules that seemed most relevant to them, to practice and apply the skills they learned, and to revisit the site as needed. Study staff had no additional contact with participants until a 6-month follow-up assessment, so the trial enabled evaluation of effects of unguided use (i.e., with minimal staff contact). Attrition was modest at 10%, and satisfaction with the program was high (e.g., 91% of website users reported having received the type of service they wanted compared to 67% in the control group). In each month of the program, 89–94% of intervention participants were using at least one skill, and on average participants were using four skills at once. At 6 months, site users had significant improvements in pain, functional status, and global impressions of improvement compared with controls. Improvement in functional status was uniquely associated with use of the exercise, pleasant activity, and problem-solving modules. It is interesting to note that as this trial was being conducted, separate pharmaceutical clinical trials were being conducted to support Food and Drug Administration (FDA) indications for three fibromyalgia medications. The same outcomes that were used in those trials were

used in the website's study. Notably, this "therapist-less" site demonstrated effect sizes (Cohen's d=.64 for pain and .38 for physical functioning) that were comparable or superior to the new FDA-approved medications for fibromyalgia. In order to achieve a 30% reduction in pain, the numbers needed to treat are 7.2, 19.0, and 8.6 for Duloxetine, Milnacipran, and Pregabalin, respectively [80]; but only 5 for "Living well with fibromyalgia" [79].

An obvious strength of this study was its use of outcomes that were being used in phase 2 and phase 3 pharmacological trials for the same condition, allowing direct comparisons between this behavioral intervention and drug therapy. Potential limitations include the use of a standard care condition rather than another website or a face-to-face intervention that could control for Internet use or modality.

Summary of unguided interventions

Relatively few automated behavioral pain management interventions have been empirically tested. In addition to the two described above, a recently published paper describes promising preliminary findings for a pilot version of an automated program that focuses on helping people with lower back pain acquire cognitive and behavioral pain self-management skills [81]. We are developing a similar program for self-management of osteoarthritis pain, called Pain-COACH. It seems likely this approach will become increasingly common, though, given its potential to be a cost-effective way to disseminate proven empirically based treatments–unguided interventions substantially minimize or even eliminate active involvement of therapists and other healthcare professionals [22].

As with therapist-guided interventions, unguided interventions vary substantially in their general approach and user interface as well as the extent to which they are information-focused versus focused on behavior change. Some incorporate social networking to enable users to exchange information and encouragement in online peer support groups. Social networking may, in conjunction with empirically tested content, provide some of the benefit traditionally provided by therapists. A potential downside is that unstructured social networking has the potential to lead to group reinforcement of maladaptive pain behaviors that could interfere with behavior change efforts. Research focused on the optimal way to implement social networking would be useful in guiding development of this intervention component.

Next, we review interventions and pain-relevant programs that leverage emerging mobile or wireless technologies and their increasing popularity.

Mobile health applications for pain management

Mobile health (*mHealth*) applications deliver health-related tools and resources using wireless devices such as smart phones and tablet computers. These devices are sometimes paired with auxiliary devices that gather physiological or mobility data in real time and transmit it wirelessly to the mobile device. These programs tend to focus on narrowly defined goals (e.g., aiding relaxation rather than training users in relaxation skills as part of a comprehensive program). Yet, their potential impact is high because they use an increasingly prevalent communication channel: 85% of American adults own a cell phone and 90% of adults (including 62% of those age 75 and older) live in a household with at least one working cell phone [82]. Members of some traditionally underserved groups (i.e., African Americans, Latinos) are more likely to access the Internet using mobile devices than are non-Hispanic Whites [83].

The examples discussed below specifically target pain management or related skills (e.g., pain tracking, training in behavioral skills shown to reduce pain). There are also applications designed to facilitate change in behaviors relevant to some pain conditions (e.g., weight loss, physical activity), but they are not discussed here.

Self-monitoring (e.g., in the form of pain tracking) is a commonly used behavioral assessment method that is sometimes incorporated into behavioral pain protocols. It can help patients become more aware of the features of their pain (e.g., its patterns and triggers) and may also provide guidance to help them adjust their behaviors to manage their pain [84]. Furthermore, by providing patients with information they can share with their provider, self-monitoring potentially improves patient–provider communication [85].

There are numerous pain tracking applications available for smart phones and tablet computers, although few are empirically tested. One program in this category won a Project HealthDesign Developer Challenge (sponsored by the Robert Wood Johnson Foundation and the California HealthCare Foundation). Called *Pain Care* (Ringful, LLC), this free application for Apple and Android devices includes a pain journal to record the time at which users experience pain, pain characteristics (e.g., its intensity, location, type, duration), pain triggers (e.g., walking, temperature changes), current mood, activity level, missed activities, loss of work time, weight, height, and free text notes. Journal entries take less 15 s to complete and use a relatively straightforward interface. For instance, intensity ratings are input with a "slider" bar enhanced with pictures of facial expressions illustrating different pain levels. Users can also get current information about pain and record pain treatments (e.g., interventional procedures, medications, therapies) and their timing. Users can also generate reports and graphs for their own information and to share with their healthcare providers to enhance provider–patient communication about pain. Furthermore, data can be stored on a password-protected companion website that offers functions such as data analytics and the ability to share data with doctors via emails that send a secure

link. The application also coordinates with several personal health record platforms (Microsoft HealthVault and Dossia). Research is needed to evaluate whether patients will use these features and, if they do, whether using them will change patients' behavior (e.g., by motivating use of adaptive pain coping strategies), their outcomes, or their communication with their healthcare providers. The same can be said of other programs in this category with similar functionality, including applications such as *Chronic Pain Tracker* (Chronic Stimulation, LLC), *PainMonitor* (Vital mHealth), *iManage Migraine* (Merck), *Pain Tracker* (iHealth Ventures, LLC), and *iHeadache* (BetterQOL, Inc.).

An extension of these applications to tracking "well behaviors" would be useful from a behavioral standpoint. For instance, users might track use of behavioral skills (e.g., pleasant activities, relaxation) and physical activity (e.g., physical therapy exercises), or positive outcomes (e.g., meeting desired functional goals). This type of application would be a useful adjunct to behavioral medicine pain interventions in that it would provide positive reinforcement by promoting a focus on positive achievement and rewards (a "celebratory" approach) [86].

In addition, there are applications designed to help users learn behavioral skills related to relaxation, based on evidence that skills such as diaphragmatic breathing and progressive muscle relaxation have calming and potentially pain-reducing effects [87–90]. Some incorporate biofeedback to help people learn to regulate biological processes (e.g., muscle tension, respiration, heart rate) with real-time feedback as they attempt to control those processes [90]. Evidence suggests biofeedback can be a useful component of multimodal pain therapies [19, 91–95]. Applications using biofeedback may include a wearable sensor that can capture and display physiological data and a wireless transmitter that sends the data to a smart phone used to store and display it. It is important to note that physiological responses can be affected by a wide variety of stimuli (e.g. temperature changes, activity level/movement artifacts, alcohol/drug intake, and presence of ongoing stressors). Therefore, users must exercise caution when interpreting readings obtained from sensors designed to demonstrate they are "relaxed," particularly if obtained in uncontrolled situations. Careful empirical validation of these devices and their data is therefore critical to ensuring their usefulness as a clinical tool.

One mobile biofeedback system in development uses a sensor in a belt to provide real-time respiration rate data. Users view a graphic visualizing their current respiration rate alongside an ideal target respiration rate, which they attempt to match. In preliminary testing this system helped users learn to slow their breathing, in turn reducing sympathetic arousal and increasing parasympathetic activity [96].

In some cases, the smart phone itself is the sensor. For instance, *BellyBio* (Relaxline) teaches diaphragmatic breathing by having users place their phone on their abdomen, where it measures changes in the angle between the phone and the user's body while providing real-time audio and visual feedback. It does not appear to be empirically tested, and its effectiveness is unclear. However, it demonstrates the potential to use technical capabilities of mobile devices in ways that are engaging and, if empirically tested, potentially effective.

Other applications use animated visual cues to help users slow their breathing. For instance, *BreathPacer* (Larva Labs Ltd) helps users slow their breathing by providing them with animated visual cues. The target breathing rate is based on the user's height, and the user has the option of reducing the target breathing rate over the course of a session. Evidence for the efficacy of this approach is needed.

Summary of mobile health applications for pain management

Use of mobile technologies for behavioral pain management is a rapidly evolving field that takes advantage of a technology many people already use. This category of interventions is dominated by untested commercially developed applications, making it difficult to characterize the number and features of currently available applications. On the whole, this category is less well developed than the categories discussed above. Few of these applications incorporate behavior change principles, and it is rare for them to be empirically tested. It is therefore usually unclear whether they help people reduce pain or even the indicators of stress they target, and the source or accuracy of their information is also typically unclear. As researchers become increasingly interested in leveraging benefits of mobile technologies, it is reasonable to expect growing availability of empirically tested behavioral pain interventions hosted on mobile platforms. As long as this field is dominated by untested applications, however, ineffective approaches to pain management are likely to be propagated with free or inexpensive applications that are easily accessed. Frequent use of ineffective approaches is problematic in that it may lead users to become demoralized about behavioral interventions and lower their self-efficacy for pain control.

MOVING FORWARD: KEY ISSUES FOR RESEARCH AND CLINICAL IMPLEMENTATION

Use of Internet-based technologies to deliver behavioral medicine interventions for chronic pain is a developing field with a great deal of promise. Although promising, barriers related to the design, implementation, and evaluation of these interventions must be addressed if these approaches are to play a significant role in increasing access to the evidence-based treatments on which they are based. In this section, we focus on systemic barriers and

research limitations that, if reduced, would help these interventions fulfill their promise to help promote better pain management and to reduce the individual and societal burden of chronic pain.

Directions for future research

This review has highlighted the state of the field with respect to Internet-based behavioral medicine interventions for managing chronic pain. There are a variety of issues that could impede their adoption in clinical practice. Issues related to clinical settings are discussed below. In addition, a critical issue is that they must, of course, be shown to improve the health and well-being of patients. Accordingly, there is a pressing need for a larger number of rigorous and methodologically sophisticated clinical trials that use adequate sample sizes and compare the efficacy of behavioral interventions to other credible interventions (e.g., Internet-based information-focused educational interventions). Currently, research on therapist-guided interventions is most well developed–albeit still in critical need of greater rigor–followed by unguided interventions and then mobile applications. A particular concern is that outcome studies usually report multiple outcomes with benefits apparent in some but often not others. Researchers need to be clearer with regard to which outcome they hypothesize to be the primary outcome their interventions are designed to change (e.g., pain reduction or improvement in physical or psychological function). Increased attention to the primary outcome of treatments would also help in tailoring and customizing treatments so they are best able to achieve the desired effect. For instance, in cases of long-standing intractable pain conditions, improvements in pain per se are unlikely to be achievable, whereas improvements in the level and range of patients' daily activity may be an achievable and key target.

There are a variety of important but unresolved research questions, including questions related to pathways through which these interventions influence outcomes. Consideration of multiple outcomes related to pain and impairment is important (with the above-noted caveat that a primary outcome must be specified), as is consideration of effects on healthcare usage, the patient–provider relationship, and disparities in pain management [97]. Studies that dismantle components of interventions to determine which are most critical to outcomes would be useful. Researchers should also consider alternatives to traditional randomized control trials such as practical trials [98–100] that test interventions in representative settings and populations and use clinically relevant control groups to address questions of interest to clinicians (e.g., relating to clinical benefit and patient adherence and satisfaction).

In addition to establishing their effectiveness, an empirical foundation is needed to guide intervention development. Translating in-person therapies for delivery via the Internet presents numerous methodological and technical challenges, and many decisions about intervention function and content are currently made without empirical guidance. One set of questions relates to methods for attracting users to an intervention and ensuring they complete intervention components (adherence or "engagement") and the intervention as a whole (retention). The concept of "treatment dose" is a related, but often overlooked, issue in these interventions. In some interventions, patients are meant to complete the entire program, whereas in others, they are meant to complete only sections that are relevant to their needs. Patients who fail to complete an intervention as it was intended to be used can be viewed as having received a lower "dose" than those who are perfectly adherent. However, the question of what constitutes "treatment dose" in Internet-based interventions is complex [101–103]. A first step in clarifying its nature and importance is for researchers to report non-usage and attrition data consistently [102]. User responses to an intervention, including non-usage and attrition, may be influenced by features of the intervention itself (e.g., its interface, content, and interactive approach) [47, 104] and user characteristics (e.g., demographics, psychological factors, and skills) [43, 89, 101]. Ritterband and colleagues [101] have developed a theoretical framework to guide development and evaluation of Internet-based interventions; it provides a useful and thorough discussion of issues to be considered.

It is also important to investigate issues related to dissemination and implementation, which have the potential to impede clinical adoption of interventions even if they are shown to improve patient outcomes. A critical area of research concerns use of these interventions in primary care, where they can serve as an adjunct to standard care delivered by physicians who treat patients with chronic pain but who have a relatively limited array of treatment options to prescribe. Particularly in light of limited reimbursements, research is needed to identify the best ways to help medical professionals integrate Internet-based behavioral pain management interventions into their clinical practice. For instance, it will be important to identify what training providers need to implement interventions and to develop methods for engaging them to ensure providers "prescribe" these interventions, follow-up in ways that reinforce their use, and use data provided by patients or the interventions themselves (e.g., patient-reported outcomes delivered directly to EMRs) to improve clinical care. Just as usability testing with patients is needed to ensure interventions meet their needs, research on implementation and practitioner engagement requires close collaboration with medical professionals [105, 106].

Systemic barriers to clinical implementation

Implementing Internet-based interventions in clinical settings presents various challenges. Practices must make choices about staff role and time commitment. Despite potential advantages of including therapists in

interventions, automated interventions are likely to proliferate more rapidly than therapist-guided interventions, in part because of their lower cost and also due to practical issues raised by having trained staff monitor or tailor treatment. If staff is to be involved, it is likely to be nursing staff already present in a provider's office. Acceptance of these interventions by medical professionals and staff is likely to be highest when interventions are shown to benefit patients and/or reduce costs, but also when they are designed to integrate with existing procedures (e.g., ongoing medication management of pain) to make them more efficient and to expand services that are offered [106].

In addition, practices making the commitment to incorporate these interventions must ensure their patients' acceptance of and adherence to interventions. Ideally, the steps they take to meet this need will be based on research on the benefits of strategies such as using reminders (e.g., emails), incentive programs, and provision of personal contact and feedback. It may also be important to select interventions with components that have been empirically demonstrated to enhance patients' motivation and interest.

Other implementation challenges stem from the early stage of this field. Many new Internet-based behavioral pain management interventions are being released. Their development is not coordinated, many are redundant, and many lack academic guidance. Healthcare professionals' ability to adopt these interventions is hindered by the fact that there is little incentive to choose one over another. No intervention is emerging as the gold standard. Furthermore, licensure issues associated with providing advice across state-lines limit therapist-guided interventions, and protection of the underlying database may limit content and functionality of automated interventions. It is also important that a clear and viable business model has not emerged for implementing these interventions in practice. The latter points underlie the reality that most empirically tested interventions are currently not available to the public.

Summary

With attention to research and systemic barriers that currently limit this field, Internet-based behavioral pain management interventions promise to advance comprehensive, interdisciplinary biopsychosocial approaches for treating chronic pain. These interventions have strong promise in large part because they are capable of meeting patients where they are –in their home environment faced with internal and external constraints that can limit their use of in-person treatments. Moreover, given the growing public acceptance of the Internet for engaging in tasks of everyday life, Internet-based interventions have the potential to contribute to what the Institute of Medicine called for in its recent report, *Relieving Pain in America* [25]: A cultural transformation in the way clinicians and the public view pain and its treatment.

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