# The Delivery of Public Health Interventions via the Internet: Actualizing Their Potential

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eHealth, World Wide Web, treatment, interactive, interactive health communication, health behavior

## Abstract

The Internet increasingly serves as a platform for the delivery of public health interventions. The efficacy of Internet interventions has been demonstrated across a wide range of conditions. Much more work remains, however, to enhance the potential for broad population dissemination of Internet interventions. In this article, we examine the effectiveness of Internet interventions, with particular attention to their dissemination potential. We discuss several considerations (characterizing reach rates, minimizing attrition, promoting Web site utilization, use of tailored messaging and social networking) that may improve the implementation of Internet interventions and their associated outcomes. We review factors that may influence the adoption of Internet interventions in a range of potential dissemination settings. Finally, we present several recommendations for future research that highlight the potential importance of better understanding intervention reach, developing consensus regarding Web site usage metrics, and more broadly integrating Web 2.0 functionality.

## INTRODUCTION

**RCT:** randomized controlled trial

**RE-AIM:** Reach, Efficacy/Effectiveness, Adoption, Implementation, Maintenance

In the early morning of December 22, 1982, Jack Buchanan, MD, posted a simple message to a USENET newsgroup—a still widely used Internet-based social-networking system. Responding to an earlier inquiry, Buchanan copied a passage from a recent edition of the CDC's *Morbidity and Mortality Weekly Report* (which, for the uninitiated, he described as a "respected newsletter type of thing"). The passage described the known etiology of a "frightening" new condition on which newsgroup members were actively seeking information. With his message, Buchanan helped to stimulate a major paradigm shift in public health intervention: This conversation was the first time that AIDS information was shared on the Internet.

More than a quarter century later, the Internet has reached near ubiquity and is generally regarded as an indispensable communication tool throughout the developed world. With the dramatic increase in Internet access has been a parallel increase in the use of the Internet as a platform for the delivery of public health interventions across a wide range of conditions and population segments. We operationalize the term Internet interventions to refer to systematic treatment/prevention programs, usually addressing one or more determinants of health (frequent health behaviors), delivered largely via the Internet (although not necessarily exclusively Web-based), and interfacing with an end user. These interventions are typically highly structured, mostly self-guided, interactive, and visually rich, and they may provide tailored messaging based on end-user data (115).

A veritable explosion in the number of randomized controlled trials (RCTs) testing Internet interventions has taken place, most emerging during the past half decade. At present, we find ourselves at an inflection point: The Internet as a platform has largely been deemed efficacious, and as the next generation of trials begins, greater attention will be needed to determine both the effectiveness and the dissemination potential of public health Internet interventions (42). Building on several recent reviews in this area (48, 69, 110, 130, 144, 152), our aims were threefold: (*a*) to review evidence on the effectiveness of public health Internet interventions, (*b*) to discuss considerations related to the dissemination potential of Internet interventions, and (*c*) to identify issues and trends that may prove fruitful for future research. Throughout, our comments are focused specifically on RCTs of Internet interventions for consumers/end-users and include both primary and secondary prevention interventions. To limit the scope, we have chosen not to include Internet systems for health professionals, clinical data management (e.g., personal health records, electronic medical records, training programs, guidelines/practice standards), assessment, survey administration, or telemetry (unless utilized within an intervention). Given our overarching interest in the dissemination of Internet interventions, we have employed the RE-AIM (41) framework to organize the discussion. RE-AIM is a planning and evaluation framework that focuses on factors critical for translating research into practice (**Table 1**).

## WILL THEY COME? THE POTENTIAL REACH OF INTERNET INTERVENTIONS

Data from the Pew Internet and American Life Project show that almost three-quarters of U.S. households have access to a home computer and nearly 75% of adult Americans are regular Internet users (those who use the Internet and send/receive email "at least occasionally"). Internet use is strongly patterned by sociodemographic characteristics. Whereas more than 92% of adult Americans aged 18–29 years old use the Internet, only 37% of adults aged 65 or older are regular Internet users (106). Internet use is more prevalent among non-Hispanic whites (76%) and English-speaking Hispanics (79%) compared with non-Hispanic blacks (56%). Among the Hispanic population, English fluency is a major driver of Internet use; although 76% of bilingual Hispanic adults are regular Internet users, only 32% of primarily

**Table 1 RE-AIM model elements, definitions, and Internet intervention example**

| RE-AIM element | Definition | Internet intervention example |
|---|---|---|
| Reach | The number and percent of those invited and eligible who participate and their representativeness | Sixteen percent of diabetes patients invited to an Internet self-management intervention participated. Those declining were more likely to be Latino and male. |
| Effectiveness | The amount of change in temporally appropriate outcomes and impact on quality of life or any adverse (iatrogenic) effects | Thirty percent of those randomized to an Internet smoking-cessation program quit compared with 12% in the control condition. The study showed no differences between conditions of weight change or quality of life. |
| Adoption | The number, percent, and representativeness of settings and staff invited who participate | Forty-six percent of work sites approached to participate in an Internet health-promotion program evaluation took part. Work sites participating were larger, had more white-collar employees, and offered more wellness activities. |
| Implementation | The extent to which a program or policy is delivered consistently, and the time and costs of the program | The average number of log-ins in an Internet physical activity intervention was 5.2. Usage decreased over the eight-week intervention, and the number of overall log-ins and use of the social support forum were associated with greater improvement. |
| Maintenance (individual level) | The long-term effects on key outcomes and quality-of-life impact | At a 6-month follow-up, an Internet weight-loss program experienced 60% attrition. Those responding lost an average of 9 pounds. A mail follow-up of initial nonrespondents revealed an average weight loss of 8 pounds among this group. |
| Maintenance (setting level) | The extent to which a program or policy is sustained, modified, or discontinued following initial trial or study period | Of 24 schools participating in an online drug-abuse prevention program, 6 continued the program unchanged, 10 requested substantial changes or added their own components, and 8 discontinued the program. |



Spanish-speaking Hispanics are (106). There remains a strong socioeconomic gradient in Internet use, with high levels found among those with a college education (93%), relative to those with high school education (67%) or less (38%). More than 50% of Internet users have a broadband connection (103). Broadband access is more prevalent among younger adults, in higher socioeconomic status households, and in urban/suburban areas (55). The racial/ethnic gap in broadband access has narrowed considerably and largely disappears after controlling for other sociodemographic characteristics and Internet use (55). The world penetration of Internet technologies is estimated at 21.9%, with the highest penetration found in the United States (73.6%), Europe (43.4%), and Asia (15.3%). Internet usage, however, is higher in Europe and Asia than in the United States. In Europe, the highest numbers of Internet users are found in Germany, the United Kingdom, and France, whereas in Asia, Internet usage is highest in China, Japan, and India. Growth in Internet usage (from 2000 to 2008) has been high across the world, but particularly in Africa and the Middle East (97, 159).

For many, the Internet serves as a ubiquitous source of access to health information. Health information on the Internet is largely trusted; nearly three-quarters of online health information seekers reported that they do not consistently check the source and date of the information that they discover (40). Given the variable quality of Internet-based health information (37), this finding is concerning. However, it perhaps lends additional support to the notion that the Internet landscape is well positioned for public health intervention.

The combination of high potential reach and efficacy suggests several possible advantages of Internet interventions compared with other modalities (41). Internet-based

implementation allows participants to access intervention content at their convenience, in a manner that can feel largely anonymous. In contrast with other public health intervention approaches intended for large populations, Internet interventions can be structured to provide highly personalized messages, based on participant data (130). When delivered via the Web, interventions can be graphically rich and engaging and make use of interactive tools. Although the initial development costs associated with Internet interventions may be quite high (and highly variable), the low marginal costs of providing service to additional individuals are believed to result in lower overall expenditures (48). Other public health intervention delivery channels with potential for high reach (e.g., television, radio, direct mail) do not offer the same potential for individual tailoring and interactivity.

## The Actual Reach of Internet Interventions

Estimates of actual reach for Internet interventions are lacking, primarily because few real-world (e.g., population-based) trials have been conducted. Many existing trials have used samples of convenience, mostly recruited offline.

Evidence of reach varies by setting. For example, in a large health system, Glasgow et al. (43) showed that an invitation to participate in an Internet weight-loss intervention attracted 2.4% of well members, 10% of those with coronary artery disease and 7% of those with diabetes. Although the proportion of those members reached was relatively small, the large sizes of the respective populations (79,378 in the general population, 18,779 with diabetes or coronary artery disease) show the potential for broad reach. Similarly, the Project Quit intervention (87) found that, after receiving recruitment letters, 7% of patients from two large health systems (more than 750,000 total) were recruited to a tailored Internet smoking-cessation intervention. Better characterizing reach in health care settings is necessary and possible, given the large number of heath systems, hospitals, health plans, and disease-management providers making major investments in their Internet services (62, 123). Whether these channels will more widely begin to offer comprehensive evidence-based Internet interventions may depend in part on demonstrations that such features can increase reach and engagement.

The employer sector continues to enhance its wellness programming with increasing emphasis on Internet offerings (53, 109). Estimates of reach, however, are just beginning to appear in the literature. For example, Graham et al. (46) tested the effectiveness of an Internet smoking-cessation intervention among IBM employees ($n = 131{,}592$) during the annual benefits enrollment period. Among the 8688 smokers identified, 6235 participated in the smoking-cessation initiative, and 1713 (28.5% of smokers) ultimately chose to utilize the QuitNet® Internet interventions.

Although online advertisements and search engine optimization strategies are rapidly maturing, little is known about the reach of purely Internet-based recruitment approaches. Cobb et al. (26) reported that as of 2004, 2400 individuals browsed the free version of the QuitNet intervention daily, with upwards of 240,000 individuals referred annually via Google searches. As part of Minnesota's tobacco settlement agreement, state residents have access to a QuitNet-powered Internet smoking-cessation intervention. In the year following its launch, more than 100,000 individuals visited the site, producing more than 23,000 program registrations (122). Similarly, Etter (33) reported that ~2% of the 50,000 monthly visitors to the French language Stop-Tabac site took advantage of the site's smoking-cessation interventions.

Much more evidence is necessary to better characterize the actual reach of Internet interventions. What evidence we currently have suggests that even though utilization rates are low at present, there is huge potential for growth.

## DO INTERNET INTERVENTIONS WORK?

Although most empirical attention has been directed toward feasibility evaluations (115), rapidly emerging evidence supports the efficacy of Internet interventions (48, 94, 130, 144, 149, 150, 161). Thus far, positive outcomes have been reported in RCTs of Internet interventions across a wide range of clinical outcomes, including asthma management (20, 30, 59, 74, 111), caregiving stress (84, 85), breast cancer coping (104, 157), chronic pain (13, 14, 15, 45, 54), congestive heart failure symptom monitoring (4, 64, 117), diabetes self management (5, 8, 11, 21, 50, 65–68, 75, 89–91), problem drinking (77, 86, 148), falls prevention (160), headache management (31, 125, 132), multiple risk behavior change (76), cardiac rehabilitation (126), HIV prevention (12, 63, 141), medical decision making (7, 16, 72), cognitive stimulation in Alzheimer's (136), mental health disorders (1, 2, 6, 17–19, 22–24, 39, 52, 60, 70, 71, 78–82, 100, 119, 124, 128, 129, 133, 140, 146, 147, 158), dietary change/physical activity (27, 49, 57, 83, 95, 98, 99, 120, 127, 143, 156), organ donation (145); pediatric encopresis (114), prostate screening, smoking cessation (33, 46, 79, 93, 107, 131, 135), sexually transmitted disease (STD) prevention (116), stress management (51), substance abuse (32, 151), tinnitus distress (3), and weight loss (44, 56, 58, 92, 118, 121, 137–139, 152, 154, 155).

Several meta-analytic reviews have sought to determine the effectiveness of Internet interventions as a group, independent of study outcome. The 2005 revised Cochrane meta-analytic review (a revision to the controversial initial 2004 release) reviewed 24 RCTs developed for patients with chronic disease (94). Support was found for positive changes in knowledge, social support, health behaviors, clinical improvements, and self-efficacy. Little evidence was identified on either economic or psychological outcomes (although cognitive behavioral treatment interventions were excluded). Wantland et al. (150) reviewed trials examining the efficacy of Web-based versus non-Web-based interventions. Among the 17 identified trials (which were composed of a wide range of populations and outcomes), 16 favored the Web-based implementation. However, only 6 of the Web-based trials showed significantly greater improvements than did their non-Web-based counterparts, and the individual study effect size estimates revealed massive variability. As with any emerging field, these early findings should be interpreted with caution. Many Internet intervention RCTs have been relatively small and underpowered, suffer from high levels of attrition, and occasionally report change in only secondary (e.g., knowledge, self-efficacy) but not primary (e.g., behavior change) outcomes.

Although there is emerging empirical support for Internet interventions, questioning whether the Internet works as a platform for intervention delivery may have inherent flaws. Doing so (e.g., in the Cochrane meta-analysis), as others have argued (35), belies the importance of specific intervention designs and components. Indeed, the approach of collapsing across extremely heterogeneous interventions and study outcomes (whether conceptually or analytically) is problematic because it masks important variation that may be necessary to understand how to improve intervention effectiveness (35). At a minimum, reviews and meta-analyses should focus on interventions for specific outcomes. Optimally, however, we will begin to see more factorial study designs testing the utility of varying intervention components.

## INTERNET-BASED WEIGHT LOSS

Even a cursory glance across the Internet interventions landscape reveals a great breadth of studies across a range of conditions, but one finds little depth in the investigation of intervention approaches for any one condition. Internet interventions for weight management, however, have been among the most widely studied.

Several RCTs have shown Web-based weight-loss interventions to be efficacious for short-term weight loss (92, 118, 121, 137–139, 152). Tate et al. (139) provided the first evidence of a successful Internet weight-loss intervention, demonstrating that an Internet behavior therapy group was more effective than Internet education in promoting six-month weight loss. A 2003 follow-up study extended these results, showing that the addition of email counseling to the Internet behavior change group increased the amount of weight lost (137). These and subsequent investigations (108), however, suggest that the magnitude of weight losses in Internet weight-loss trials is less than that found for individual or group treatment approaches.

Greater weight losses are typically observed for Internet weight-loss interventions that are highly structured, provide support from a human counselor, utilize tailored materials, and promote a high frequency of Web site logins (108, 118, 137–139). Nevertheless, several challenges remain for Internet weight-loss interventions. The current generation of interventions are characterized by the use of varying intervention components (self-monitoring, food diaries, BMI calculators, support forums, coach messaging), and it is largely unclear which of these features (either in isolation or collectively) are associated with the greatest magnitude of weight loss. Participant attrition is generally high (usually greater than 25%), and among those participants who are retained, engagement rates typically drop over time. A further challenge is that, not unlike traditional approaches, the bulk of weight losses are produced within the first six months of intervention, and there is little evidence that Internet interventions can effectively promote weight-loss maintenance (134).

## IMPLEMENTATION ISSUES

Across the myriad intervention strategies appearing in the literature, several implementation-related themes have emerged that should be addressed to improve study outcomes.

### Minimizing Attrition

In his "law of attrition," Eysenbach argued that high rates of participant attrition, in the form of both dropouts and losses to follow-up, represent one of the "fundamental characteristics" of Internet interventions (34). Attrition rates in the 40%–50% range are not uncommon.

The primary source of attrition in Internet interventions is likely not elusive; many participants simply lose interest over time. Most Internet interventions are of low intensity and are not highly structured, and most investigators expect a high degree of individual variation in Web site utilization. Although the easy lifestyle integration and perceived privacy associated with Internet interventions participation may prove initially attractive, if site content is not continually made salient, participant interest may wane. In contrast with in-person interventions, some recent data illustrate that individuals who fail to complete follow-up assessments for Internet interventions may still derive as much intervention benefit as those who do not (28). Interestingly, recent evidence (29) suggests that a large proportion of individuals believed to be lost to follow-up can be assessed by changing assessment modalities; mailed follow-up surveys may be particularly effective in this regard. Future Internet intervention trials should routinely present comparisons of those who complete assessments relative to those who do not. In addition, nonresponse follow-up studies (29) and formal modeling of attrition (34) are highly recommended.

### Promoting Utilization

Web site utilization is one of the more consistent predictors of positive outcomes. However, Web site utilization tends to drop rather precipitously after the initial weeks of intervention participation (57). Unfortunately, we know little about those factors (at the individual or group levels) that are associated with sustained Web site utilization. In the absence of such data, a number of strategies have been employed with some success. For example,

several investigators (24, 113) found improved outcomes with the use of "push reminders" (postcards, email, telephone calls). Additional strategies may include using incentive programs (e.g., raffles, point systems, and giveaways) and self-monitoring systems (that stimulate frequent return visits), managing participant expectations prior to trial enrollment, minimizing usability challenges, and providing personal contact and positive feedback (34, 93). Use of human counselor support may also drive increased utilization; however, it may constrain intervention reach and increase costs. Finally, strategies designed to promote Web site utilization may also protect against attrition.

### Tailored Messaging

As noted by Strecher (130), the Internet is replete with "digital pamphlet racks." These sites simply relate general health information online, rather than taking advantage of the opportunity to tailor health messages, which can be accomplished efficiently via the Internet. Emerging evidence supports the use of tailored messages in Internet interventions (135, 138). Briefly, the tailoring process combines large repositories of varying health messages with individual-level participant data to provide highly individualized health messaging to the individual (73). Tailoring can be performed on any number of individual characteristics (e.g., age, gender, location, self-efficacy, readiness) and has been shown to outperform traditional, static health information strategies across a wide range of outcomes. An important area of future research is to determine how and under what circumstances tailored messaging might be used most effectively to stimulate sustained Web site utilization (130). Although most investigators accept that tailored approaches are preferable, few trials have systematically determined the type or extent of tailoring necessary by outcome. Tailoring complexity has a strong relation with the associated costs (at least during development), and given the wide variety of potential variables that can be used to tailor messages, guidance about best practices is needed.

### Social Networking

Throughout its history, the Internet has served as a hub for social interactions, as evidenced recently by the rise of social-networking Web sites. Tools to facilitate social support (both between peers and with human counselors) have strong anecdotal, but more limited empirical support. Eysenbach's 2004 review (36) of "virtual communities" and electronic support groups found little evidence that participation in peer-to-peer social-networking communities was associated with change in health outcomes. However, the literature has produced no examples of trial designs that would allow for systematic investigation of the relative benefits of various social-networking features. There are several important, unanswered questions in this area. Is social networking more useful for some outcomes (e.g., weight loss, physical activity promotion, smoking cessation) than for others (e.g., pediatric enuresis, HIV/STD prevention)? What are the relative benefits of professionally moderated versus unmoderated social networking? Does intervention efficacy vary as a function of whether an individual chooses to affiliate with (versus being assigned to) a given social network? Are specific social-networking designs (e.g., information aggregation, forums, blog-style comment systems, syndicated content strategies) associated with differential Web site utilization?

## THE POTENTIAL FOR WIDESPREAD ADOPTION AND MAINTENANCE OF INTERNET INTERVENTIONS

Given their potential for low costs, scalability, adaptability, and effectiveness, Internet interventions may be appropriate for dissemination to a range of settings (e.g., health systems, health plans, employers, municipalities). However, each of these settings varies considerably with regard to their resources, expertise, interest, and ability to implement Internet interventions independently. There has been relatively little discussion of contextual issues related to

adopting these interventions, but several factors may be important to consider.

Scaling an intervention for delivery to a large population is a nontrivial endeavor. Most research intervention sites are hosted on shared servers, a low-cost, easily administered solution that is appropriate for the low volume of traffic often encountered in research studies. However, at scale, different architectures (e.g., multiple servers, application servers, search databases, session databases, and redundant storage systems) are necessary. Investigators likely need not be proficient in Internet systems architecture; however, greater understanding of scalability processes can help better characterize the potential for adoption in settings of interest.

An inverse association likely exists between population size and the marginal costs of intervention implementation. Consequently, attention is needed to understand better the adoption considerations required for effective dissemination to smaller settings (e.g., rural practices, community health centers, small municipalities). Because smaller settings may be unable to make the infrastructure investments necessary to support high-quality Internet interventions, strategies are needed to overcome these resource constraints. One possibility would be to develop a federally supported, market-competitive, Internet intervention infrastructure that could be leveraged by investigators to disseminate interventions to interested parties.

Cost considerations will remain primary drivers of adoption, and studies should estimate market costs for maintenance, ongoing implementation, and intervention scalability to communicate effectively with potential dissemination settings. Cost-effectiveness analyses are important but may not hold considerable sway, as the metrics frequently employed by academics (e.g., quality adjusted life years) may not be consistent with the interests of potential dissemination settings. Some settings (e.g., health plans and large self-insured employers) may be interested primarily in medical cost savings. However, for many clinical outcomes (e.g., weight loss), cost savings are not observed, making nonfinancial interests (e.g., member satisfaction, case finding) more salient. Employers, large and small, may be motivated to adopt Internet interventions to improve productivity, enhance employee participation, create healthier workplace cultures, and improve their standing as socially responsible organizations. Thus, change in behavioral and/or clinical outcomes may not be the primary adoption consideration for many dissemination settings. Academic investigators should more frequently form research partnerships with potential dissemination settings to understand adoption considerations better and to structure more sustainable intervention delivery strategies.

## FUTURE DIRECTIONS

The promise of Internet interventions lies in their dissemination potential. Several considerations may help to realize the goal of widely disseminated public health Internet interventions.

### Better Characterize the Reach of Internet Interventions

Many papers reporting on Internet interventions describe the latest national data on computer use and Internet penetration (we have done the same here). The intention is usually to demonstrate the broad potential reach of Internet interventions and to provide additional justification for the choice of an Internet-based design. As we have shown, what direct evidence we have on reach is very limited.

Recall that reach refers to "the absolute number, proportion, and representativeness of individuals who are willing to participate in a given initiative, intervention, or program" (41). Many Internet interventions are structured for clinical conditions (which may have low prevalence in the general population). Even the growing number of sites with a primary prevention focus are most frequently focused on a single outcome (e.g., smoking cessation, dietary change) and, as a consequence, may appeal to a relatively small niche portion of the overall

population with computer and Internet access. A better understanding of the true reach of Internet interventions is needed. Such efforts will require methods that characterize the representativeness of the study sample. Investigations should much more frequently report the size of the target population, proportion of the target population exposed to recruitment, proportion of the individuals who are eligible, proportion of eligible individuals who participate, and the representativeness of those persons (61).

These considerations are particularly necessary because many existing trials of Internet interventions have been conducted primarily in small, select samples. The few population trials have shown generally low reach rates, despite their use of high-quality Internet interventions. For example, Glasgow et al. found that only 2%–5% of overweight adult members of three large managed care organizations participated in a free Internet weight-loss program. Perhaps most challenging was that key population segments—those over age 60, smokers, those estimated to have higher medical expenses, and males—were less likely to enroll (43).

Studies with population designs are needed to better characterize reach (61). Primary prevention trials might examine reach rates in the general Internet population, with particular attention directed toward defining optimal recruitment strategies. Trials within health systems, health plans, and employers are also needed, given their considerable potential as dissemination channels. Finally, trials in patient populations might enroll those in hard-to-reach settings (rural areas, locations without sufficient health care options) or for conditions that require ongoing monitoring or specialized care information (e.g., congestive heart failure).

## Standardize the Reporting of Usage Metrics

We have argued against the approach of making comparisons across Internet interventions that are heterogeneous with respect to design and outcome. However, one area where the field may want to ensure comparability is the reporting of Web site usage metrics. It is problematic that the definition of common usage metrics has varied by study because there is potential for significant variation in utilization rates. Some studies have assessed usage with simple counter hits systems (154), whereas others have used username/password entry (38, 105). Some have used sophisticated third-party tracking systems (88), and others have used time-stamps of Web site activity (96). Many have not provided sufficient details on their Web use tracking strategy (24, 25, 112, 122). Given the relatively consistent evidence that participant Web site utilization predicts positive outcomes across a wide variety of conditions (26), better comparability can be ensured by encouraging uniform standards for the reporting of individual Web site usage.

Although it is common for nonacademic sites, there has been little reporting by researchers of aggregate Web utilization for Internet interventions; doing so, however, is necessary to characterize Web site usage patterns. Analytic products offered by Google, Yahoo, and Microsoft are sophisticated and very widely used. Each produces a set of standard usage metrics (e.g., page views, visits/sessions, unique visitors, repeat visitors, page views per visit, visit duration) and requires only that a small amount of code be entered onto an intervention Web site. Basic functionality for all three products is free. Developing consensus regarding the presentation of Web site usage metrics, at both the individual and aggregate levels, is an important evolutionary step toward understanding how participant engagement affects intervention outcomes.

## Enhance Effectiveness: Internet Interventions Version 2.0

A fundamental challenge for the dissemination of Internet interventions is reconciling how researchers can be most effective when (*a*) innovations frequently occur outside of the academic setting, often more rapidly than they can be tested, and (*b*) the design, features, and platforms of research Web sites frequently lag their

commercial/open-source counterparts. What is striking when one reviews the current generation of Internet interventions is that few of the innovations characteristic of modern, highly trafficked Web sites have been fully leveraged in research intervention designs. Arguably, the most important design gap concerns the limited use of Web 2.0 features in the current generation of Internet interventions.

During the past five years, while the first generation of Internet intervention RCTs was being conducted, Web 2.0 sites such as YouTube and Flickr were changing the way that individuals store, manage, and syndicate their personal data. Digg, Reddit, and Newsvine shaped how people interact with news media. Facebook, MySpace, and Friendster launched a social-networking revolution. And a host of new terms—wikis, tagging, mashups, feeds, blogs, podcasts, widgets—entered the lexicon. Although the precise technical bounds of the Web 2.0 definition remain hotly debated (153), it cannot be disputed that the most highly trafficked modern Web sites, to some degree, have integrated Web 2.0 design principles.

The term Web 2.0 refers to a loose set of design principles, key elements of which are presented in **Table 2**. At its most basic level, Web 2.0 is about the progression away from Web sites and toward Web services, applications that are native to the Internet and allow individuals to exert a high degree of control over their own data. Web 2.0 designs are usually under continual development, via the efforts of developers and end users. Web 2.0 applications offer new ways for users to store, view, manipulate, share, and experience their personal data. Interfaces are graphically rich and engaging, but they are fundamentally about functionality, particularly those functions that facilitate social interactions and the development of collective wisdom (101).

Why is this important for public health Internet interventions? First, the efficacy of the Web 2.0 approach to attracting, retaining, and engaging end users has been well demonstrated; indeed, nearly all major media, social networking, and e-commerce sites incorporate Web 2.0 principles. At a time when the Internet intervention world needs to more rapidly develop strategies to prevent attrition, use of these demonstrated principles is advisable. Next, Web 2.0 design conventions involve allowing users to manage, display, and share their data in sophisticated ways. Take self-monitoring, for example. Creative implementations of Web 2.0 principles could open the doors to new ways of engaging individuals to monitor their health behaviors. To illustrate, nearly a half-million people utilize the Twitter Web site simply to post in real time (using a Web site, mobile device, instant messaging) information about what they are doing at that moment. Self-monitoring interfaces might also be created to be accessible through multiple modalities that would be graphically engaging and have features that would allow for syndication. Imagine a smoking-cessation intervention during which participants could post their cigarette use in real time and share them with friends and family members to review, so that encouragement can be provided. Doing so using Web 2.0 principles requires attention to how individuals want to display, access, and share data, through the development of interfaces that are primarily for participant use, rather than predominantly for research purposes.

As noted, we have yet to capitalize on the phenomena of social networking in Internet interventions. Although there is little empirical evidence on the issue, there is robust anecdotal discussion that despite our best efforts, forums, message boards, and chat rooms are rarely used in Internet interventions. The demonstrated success of Web 2.0 principles in designing social-networking applications can be leveraged to Internet interventions created in academic settings. For example, PatientsLikeMe is an online social community for patients with a variety of complex chronic diseases such as Parkinson's, multiple sclerosis, and HIV/AIDS. In addition to a standard set of social-networking features, the Web site asks patients to self-monitor their experiences, medications, symptoms, drugs, and dosages. These data are

**Table 2 Selected Web 2.0 components and implication for public health Internet interventions (101, 102)**

| Component | Description | Implications for public health Internet interventions |
|---|---|---|
| Architecture of participation | Systems should aggregate user data, building additional value secondary to ordinary use of the program. Systems should improve as more people use them. | More frequent use of participant data is needed to drive intervention content (e.g., deeper tailoring algorithms, presentation of narratives, matching of similar participants, collaborative filtering). Social-networking features can be central to intervention design (rather than having only forum and/or chat functions) and allow users to share data among other intervention participants and with nonparticipants (via syndication). |
| Remixable data source and data transformations | Internet applications should be data driven, allow users control over the data, and permit the data to be used in a variety of ways. | Functionality is needed to allow data to be manipulated by the participant, displayed in various ways, syndicated, and made available for data mining (both by the user and the system). Interventions should develop and/or utilize external APIs that permit the integration of site data with other systems. |
| End of the software release cycle | Systems are in perpetual development, constantly being maintained, with rolling delivery of new features, modifications, and bug fixes based in part on user input. | Workflow and staffing plans should be created that anticipate the ongoing development, maintenance, and improvement of site features. Developers should invite and act on participant suggestions. |
| Software above the level of a single device | Systems should be accessible through and ultimately link data from across a range of devices. | Systems should be developed that permit users to access their data through multiple sources (e.g., PCs, mobile phones, interactive voice response, text messaging, televisions); doing so may, in part, minimize challenges presented by the digital divide. |
| Harnessing collective intelligence | Systems are based on the aggregate activity of users (e.g., eBay, Craigslist) and/or utilize user contributions as core functionality (e.g., Amazon, Wikipedia, YouTube). | Expert systems should embrace and utilize participant data and utilize collaborative filtering to match individuals with similar behaviors/barriers. Systems should allow participants to contribute to site functionality, rather than simply using it. Systems should have features that allow participants to share and learn from the experiences of others in an authentic manner. |



aggregated and displayed to other site members for review and discussion. In this way, site members are empowered to contribute to and utilize the collective wisdom and experiences of their counterparts to become more informed about their own condition.

We suggest that closing these design gaps should be a high priority in future Internet intervention trials. There should be few theoretical barriers to prevent the widespread integration of Web 2.0 principles in Internet interventions. In fact, most existing Web 2.0 sites have relied (at least in part) on behavioral and social processes that would be familiar to the public health community. For example, YouTube allowed individuals to share videos with others in their social networks. News aggregation sites such as Digg and social tagging sites such as Del.icio.us allowed end users to collaborate actively to popularize information that they find important. Google Health, the recently announced personal health record system, can be tightly integrated with behavioral interventions. Web-based social networking itself—a phenomenon facilitated by technological innovations—ultimately relies on theories that have been discussed by social scientists during the past half century (10, 47, 80, 142).

The public health community can contribute to and benefit from more frequent consultation with industry experts (Web designers, business leaders, social media experts, Ajax programmers) to spur innovation. Public health researchers should be involved more frequently in the evaluation of existing, consumer-directed (including commercial) intervention programs. Investigators have conducted several such evaluations of major commercial smoking-cessation and weight-loss Web sites (44, 122), but much more can be done in this area. Another possibility is the development of interventions for use within popular Web sites. Many sites offer application programming interfaces (API) that permit utilization of site functionality. For example, the concept of Google mashup involves linking geographic information available through the Google Maps system with some other source of information (e.g., real estate data), thereby creating a new Web application. The highly popular Web site, Facebook, opened its service to application developers in 2007, resulting in many thousands of new programs and several health intervention systems. This ease of integration suggests that we might strive to build more interventions that integrate with highly popular Web sites to mitigate some of the issues related to recruitment, reach, and retention, while taking advantage of new functionality.

## CONCLUSION

Many of the efficacy reports on Internet interventions for public health issues have been encouraging, including the majority of controlled studies. However, much remains to be done especially to align research evaluations better with the types of programs that are rapidly evolving in the marketplace. Many papers discuss the potential of Internet interventions, but this potential has been seldom documented, especially in areas such as program reach, the breadth and sustainability of effects, and reporting of standardized measures of Web site utilization.

We especially recommend investigations of strategies to enhance engagement with Internet interventions over time and that reduce the ubiquitous high rates of attrition in such studies. Much greater use of Web 2.0 features such as social networking is likely to be necessary to remain relevant and to facilitate dissemination. However, it may not be practical for the research community to expect, or be expected, to keep pace with the rapidly evolving technologies emerging within the marketplace. Indeed, research approaches are needed that combine features of rapid quality-improvement strategies with more traditional controlled evaluations. The ongoing discussion regarding the utility of time series designs as alternatives to the RCT for testing community-based behavioral interventions may be useful for developing future Internet intervention trials (9). Nearly all Internet interventions tested to date have been individually focused. Innovative multilevel approaches, as well as strategies that tap contextual features, are needed and may be particularly efficacious among socially disadvantaged populations. Finally, the field needs to move beyond global questions, such as, "Does the Internet work for health promotion?," to more nuanced questions, such as, "Which features are associated with which outcomes, and how are these outcomes derived?"

### SUMMARY POINTS

1. In the past decade, there has been increasing interest in the use of the Internet as a platform for the delivery of public health interventions.
2. Although the potential for broad population reach with Internet interventions is substantial, the current (albeit limited) evidence suggests that there are low levels of actual reach across a range of settings (e.g., health care, employers).

3. Several implementation considerations may improve Internet intervention study outcomes. Studies should employ recommended strategies to minimize the frequently elevated rates of attrition and increase Web site utilization. Tailored messaging and social-networking functionality may increase the uptake of Internet intervention content.
4. The future of Internet interventions lies in their dissemination potential. It may be necessary to take steps to align research sites better with the types of programs that are rapidly evolving in the marketplace. This action will require greater attention to closing several design gaps and more broadly integrating Web 2.0 functionality into research Web sites.



## DISCLOSURE STATEMENT

The authors are not aware of any biases that might be perceived as affecting the objectivity of this review.

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