Past, Present, and Future of eHealth and mHealth Research to Improve Physical Activity and Dietary Behaviors

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Abstract

As physical inactivity and unhealthy diets are highly prevalent, there is a need for cost-effective interventions that can reach large populations. e- & mHealth solutions have shown promising outcomes and have rapidly expanded in the past decade. The purpose of this report is to provide an overview of the state of the evidence for the use of e- & mHealth in improving physical activity and nutrition behaviors, in general and special populations. The role of theory in e- & mHealth interventions, and methodological issues are addressed. Key recommendations for future research in the field of e- & mHealth are provided.

Keywords

behavior change, intervention, diet, nutrition, physical activity, health, e-health, m-health, information technology, apps, smartphone, mobile, web-based, online, Internet

INTRODUCTION

Physical inactivity and poor dietary behaviors are major risk factors for a number of non-communicable diseases including cardiovascular disease, type 2 diabetes and some cancers.[1-3] In 2010, it was estimated that collectively, physical inactivity and dietary risk factors accounted for 10.2% of all disability adjusted life years globally.[4] National estimates from high-income countries including Australia, Canada, the United Kingdom and the United States, suggest that 1% to 2.6% of total healthcare costs are directly attributable to physical inactivity.[5] Similarly, in the United Kingdom food related ill health is responsible for 10% of morbidity and mortality and costs 6 billion pounds annually.[6] As a consequence, improving the population's physical activity (PA) and dietary intake is a recognized public health priority.[7]

To address the increasing rates of obesity and chronic diseases, a multitude of behavior change interventions that aim to improve PA and dietary behaviors of individuals have been developed.[8] Most of these interventions – whether targeting a single behavior (PA or dietary behaviors alone) or multiple behaviors (PA and dietary behaviors in combination) – have been delivered in face-to-face settings, which is expensive and inhibits large-scale implementation.[9,10] Thus, cost-effective interventions that can improve dietary behaviors and PA in large populations are needed.[11,12] Such interventions represent a public health approach that could significantly impact the global burden of chronic disease whilst also being affordable.[4]

Electronic and mobile health (e- & mHealth) technologies, including the Internet, mobile devices and smartphone applications ('apps'), provide opportunities for population-wide promotion of PA and healthy eating.[13,14] The precise definitions of eHealth and mHealth vary due to being applied in differing contexts and due to the ongoing development and advancements of information technologies that lead to new applications for e- & mHealth.[15]

However, for the purpose of this report eHealth is defined broadly as *'the use of information and communications technology, especially the Internet, to improve or enable health and healthcare'*,[16] and mHealth, which is a subdivision of eHealth, is defined as '*medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices (e.g. heart rate monitor), Personal Digital Assistants (PDA) and other wireless devices'*.[17]

By the end of 2014, it was estimated that there were almost 3 billion Internet users, and 2.3 billion mobile-broadband subscriptions globally.[18] Given the rapid growth in internet accessibility and improvements in technology it is not surprising that research into the use of e- & mHealth interventions targeting lifestyle behaviors has burgeoned in the past decade.[19–25] This report sets out to provide an overview of the current state of the science of e- & mHealth PA and dietary behavior intervention research. The report further addresses the use of e- & mHealth in underserved populations, the use of theory and methodological issues. The report closes with providing recommendations for future research foci.

Status of e-Health in Behavioral Research

Several reviews and meta-analyses of behavioral eHealth interventions have been conducted. In relation to dietary interventions, a review by Harris et al.[26] concluded that eHealth interventions to promote dietary behavior change do not produce clinically significant changes in dietary behavior and, are at least as, expensive as other individual behavior change interventions. However, a more recent review of reviews by Tang et al.[27] demonstrated support for the effectiveness of self-directed (i.e. mostly eHealth approaches) weight loss interventions, but indicated low quality for most reviews (14 out of 20), limiting confidence in the outcomes.

In relation to PA, Davies et al.[19] conducted a meta-analysis and found web-based interventions significantly improved PA in the short-term (the *Cohen's d* effect size was 0.14), and particularly when targeted at inactive participants (d = 0.37). However, long-term maintenance of behavior change, as well as engagement and retention of participants was problematic. A review specifically focusing on eHealth interventions amongst children and adolescents, demonstrated strong support for such interventions, with seven out of nine interventions significantly improving PA.[28]

Some reviews have focussed on eHealth interventions simultaneously targeting dietary behaviors and PA. For example, a review by Hou et al.[29] found evidence for strong positive outcomes for both PA and dietary behavior change in such interventions. The meta-analysis by Cushing et al.[30] found positive outcomes for eHealth interventions in children and adolescents, and highlighted differences in effect sizes for interventions that were purely educational (d = .03) versus those that also included behavioral components (e.g. goal setting, self-monitoring; d = .35). These outcomes are in line with a review of reviews by Kohl et al,[31] which highlighted low participant engagement with eHealth intervention platforms as a key limitation to date, and contributing to small and unsustainable effect sizes. They indicated that there is currently no need to conduct more 'effect studies', rather research is needed to identify which components within eHealth interventions are effective, as little is known about the determinants that drive effectiveness within these interventions.

One specific intervention component that has received great attention when evaluating eHealth interventions is the use of computer-tailoring where participants receive personalized feedback based on answers to an online survey. Neville et al.[32,33] conducted two reviews on the effectiveness of web-based computer-tailored interventions which found overall positive outcomes; in one review they found that 10 out of 16 interventions significantly improved PA; in the other review they found that eight out of 12 interventions significantly improved

dietary outcomes. However, a similar review, also focusing on web-based computer-tailored interventions that combined outcomes for PA and diet, concluded that tailoring was more effective for nutrition interventions compared to PA interventions.[34] Krebs' et al.[35] meta-analysis found that effect sizes were indeed somewhat larger for dietary computer-tailored interventions (d = .22) compared to tailored PA interventions (d = .16). Importantly, however, this meta-analysis also demonstrated that effect sizes increased when the computer-tailored interventions were dynamic (having multiple assessment and feedback cycles) and did not decrease when PA and diet were targeted simultaneously. In relation to eHealth interventions it is important to consider that small effect sizes do not necessarily mean small public health impact, as these interventions have the potential to reach more people compared to traditional face-to-face interventions.

Brouwer et al.[36] conducted a systematic review specifically examining which characteristics are effective in increasing exposure to Internet-delivered interventions, as increased exposure to intervention content has consistently demonstrated to increase intervention effectiveness.[37] They found that eHealth intervention components such as provision of peer support, counsellor support, e-mail/phone contact and website updates were significantly associated with increased exposure. Webb et al.[38] focussed on the influence of using health behavior theory in internet-based interventions and found that more extensive use of theory was associated with increases in effect size; particularly, interventions that used the Theory of Planned Behavior tended to have substantial effects (d = .36). Additionally, interventions that incorporated more behavior change techniques also tended to have larger effects. Despite the frequent use of behavior change theory in academic-led eHealth interventions, Vandelanotte et al.[39] audited freely available PA websites and found they tend to lack the fundamental components associated with behavior change. However, the increasing presence of social media applications in most websites was encouraging.

The use of online social networks (e.g. *Facebook, Twitter,* or purpose-designed health online social networking sites) to improve health behaviors was addressed in a systematic review by Maher et al.[25] They reported generally small effect sizes, as well as difficulties with intervention engagement and retention, despite some of the interventions being delivered on existing online social network platforms with proven engagement and retention. The authors observed that most interventions to date had not incorporated characteristics of popular social networking (such as convenience of communication, enjoyment, and emphasising interactions with existing friends).

In summary, there is a considerable body of scientific literature regarding eHealth behavior change interventions. To date, evidence suggests such interventions can lead to positive, short-term changes in behavior, that tailoring is a useful intervention element, and that theoretical underpinning is important. However, further work examining how to maintain behavior change into the longer term, identifying which intervention elements are effective, and responding to new intervention opportunities as technology advances, is required.

Status of m-Health in Behavioral Research

High penetration of mobile devices and the use of new and powerful smartphone apps provide opportunities to expand the reach of diet and PA behavioral mHealth interventions.[40] Mobile phones, personal digital assistants (PDAs) and body sensing systems have been used to assess PA, sedentary behavior and dietary patterns, as well as to deliver feedback, information, and support to participants of behavioral interventions.[41–43] A review of dietary assessment methods deployed on mobile platforms found that the feasibility and validity of mobile phones to assess dietary intake were not superior to but equivalent to, traditional interviewer- or self-administered paper/pencil methods.[44] Notably, participants' self-reported satisfaction and preferences for mobile phone methods were higher than conventional

methods. A review of PA assessment methods using smartphones found a wide variety of assessment tools either using smartphone apps (i.e., using tri-axial acceleration data from the phone's native sensor) or on-body sensing systems (i.e., external accelerometer devices) that were positioned on different body parts (e.g., hip or waist). Algorithms were used to recognize a range of activities (e.g. walking, running) and postures (e.g. standing, sitting). Overall, the 10 included studies reported moderate to high validity with measurement accuracy ranging from 52 to 100%.[23]

In terms of efficacy of mobile technologies in promoting healthy diet and PA, a 2012 meta-analysis suggested interventions using personal digital assistants (PDA) and mobile phone text messages (SMS) were moderately effective in increasing PA behavior (the *Hedges' g* effect size was 0.54).[42] This finding was echoed in later reviews that focused on interventions utilizing SMS, PDA, interactive voice response systems, smartphone apps and wearable devices (e.g. Fitbit) to promote PA.[23,43,45–49] Similarly, Lyzwinski found a pooled medium effect size for weight loss interventions using mobile phones,[50] PDA's and MP3 players compared to varying controls (d = 0.43). Further, most of the included studies reported positive changes in terms of body mass index (BMI), waist circumference, percentage body fat, and dietary behaviors. These findings are in accordance with a meta-analysis on weight management interventions delivered via SMS.[51] While Lyzwinski's weight loss study suggests that mHealth applications have been effective in improving dietary behaviours to date there is no equivalent systematic review/meta-analytic study of the effectiveness of mHealth interventions on dietary behavior. However, in the first instance there remains an urgent need for more robust and large-scale efficacy trials in both diet and PA applications of mHealth.[23,52]

Content analyses of mobile apps[53–57] have been conducted to identify apps using evidence-based behavior change techniques,[58–60] as well as diet and PA recommendations.[61] These

investigations collectively indicate that health and fitness apps available on iTunes and Google Play utilized few or no behavior change techniques, and infrequently incorporated evidence-based recommendations. For example, Conroy et al.[62] analyzed the online descriptions of popular health and fitness apps and reported that most apps targeting PA are using behavioral strategies that can be categorized into improving motivation and providing behavioral education, while action planning as a successful strategy was rarely used. Further, it was unclear how the respective behavior change techniques were implemented and therefore no conclusion could be drawn whether they are as effective as face-to-face interventions, or whether a parsimonious set of "effective" techniques outperforms apps that include less effective techniques.[56] Most commercially available apps are not developed in partnership with behavioral experts, thus, this might explain why evidence-informed content and engagement techniques are notably scarce.[54,55,61] The inclusion of such experts in the development process may increase the likelihood of success.[57]

e- & mHealth in Underserved Populations and the Developing World

With the use of new technologies, formerly isolated populations are now reachable. This presents an opportunity to conduct health interventions in traditionally underserved groups,[62,63] particularly for those whose demographic, geographic or economic characteristics negatively affect health care access and delivery,[64] such as older adults, people with low socioeconomic status, ethnic minorities, gay-lesbian-bisexual-transgender people, people with disabilities and those living in low to middle-income countries.[65] However, only a limited amount of research has been conducted in relation to e- & mHealth in these populations.

With regard to e- & mHealth research in ethnic minorities, most studies are small feasibility trials, conducted in the United States, limiting the generalizability of the study results. Two

small studies in African Americans used SMS to encourage weight-loss and increase overall PA, respectively. In both studies SMS was effective for weight loss over six months[66] and increasing PA levels[63] respectively, illustrating the potential of this type of intervention. Similarly, the use of PDAs has been effective to improve dietary intake in economically disadvantaged girls from an ethnic minority in the United States.[67] Finally, in a systematic review of eHealth weight management interventions in overweight and obese ethnic minorities in the United States,[68] four of six studies reported that significantly greater weight loss occurred in the eHealth conditions compared to control conditions. The authors, however, highlighted that further research is needed because eHealth interventions were not compared with non-eHealth approaches, and the extent to which weight loss was achieved in these studies was not considered clinically meaningful.

e- & mHealth research in older adults is scarce with only one review available focusing on non-face-to-face PA interventions in older adults.[69] Only four out of the 16 included studies used e- & mHealth in some form, however three of these showed a significant positive impact on PA with medium to large effect sizes. Technology use in older adults is growing rapidly (e.g. about half of Americans over 65 years of age regularly used e-mail or internet), this highlights the potential for future e- & mHealth research.[70] Recruiting people with disabilities in e- & mHealth trials seems particularly challenging, and only one paper could be identified that described an 8-week internet-based intervention to increase PA in adolescents with cerebral palsy.[71] After the intervention, a significant increase in walking was observed in the intervention group, however the intervention effects disappeared after 20 weeks.

Globally, low- to middle income countries are in high need of sustainable and cost-effective behavioral diet and PA interventions due to the steep increase of non-communicable diseases.[71] The use of mHealth may be more promising than the use of eHealth in developing countries due to the rapid growth of mobile phone ownership, in contrast to the number of

people having access to or ownership of computers with an Internet connection.[18,52,73] One systematic review has targeted mHealth interventions in low- to middle income countries. The authors included 76 studies, 20 of which focused on health education and behavioral change.[62] However, most of these studies focused on health behaviors related to infectious diseases, with only two SMS-based studies (one in South-Africa and one in India) focused on type 2 diabetes prevention and reported on diet and PA outcomes.[74,75] The South-African study (N = 22 females) was not able to significantly improve step counts, healthy eating and BMI, however participants were regularly texting their peer support buddies.[74] The Indian study (N = 537 males) showed significant improvements in the diet of intervention group participants, but not in PA.[75]

It is clear that there are great opportunities to advance the science in this area. It is important to point out that not all groups are able to take advantage of e- & mHealth services, not only because of a lack of access to computers, mobile devices and the Internet (i.e., the "digital divide"), but also because individual, social and cultural barriers relating to internet self-efficacy, health literacy, and cultural/linguistic appropriateness.[76] Despite the increasing popularity of the internet, there is overwhelming evidence of inequalities across the dimensions of access to and use of communication media, the processing of health information, and the effect on health behaviors.[77,78] This suggests that access alone is not enough, and that how and where information is presented, organised and disseminated is equally important.[76] Currently, limited information exists on how to best operationalize intervention content and strategies to maximise use among underserved populations.

The Use Of Theory in e- & mHealth Interventions to Enhance User Engagement

In the context of e- & mHealth interventions, 'engaging' interventions are those that entice users to be involved with the intervention platform. As such, engagement is often assessed in

terms of intervention usage (e.g., number of logins, number of modules completed, pages viewed). There is consensus among researchers that the application of theory to the development and evaluation of health behavior change interventions significantly improves behavioral outcomes.[79] Theories help pinpoint *what* factors need to be considered when designing interventions; provide insight into *how* to target these factors; and provide insights into *why* an intervention works.[79,80] To date, the majority of discussions and research involving the application of theory to the development and evaluation of health behavior change interventions has focused on theories concerned with psycho-social and environmental determinants of health behavior.[79–83] Overall, while these theories provide guidance in the development of intervention content, they provide little insight into how to design engaging interventions that effectively prompt recommended patterns of intervention usage.[84] Consequently, e- & mHealth interventions are often developed without explicitly giving consideration to attributes influencing attitudes, online behavior and health behavior change. This may partially explain the modest effect-sizes reported in e- & mHealth interventions and why issues associated with user engagement (e.g., low use of intervention features, few logins, non-usage attrition) are consistently reported.[19,84] Notably, in a recent review of the eHealth literature (involving over 80 studies), only 50% of participants on average were found to engage with the intervention platform as intended by intervention developers.[85]

Findings from systematic reviews and meta-analyses support the notion that intervention characteristics associated with user engagement (e.g., tailoring intervention content to match individual characteristics, website interactivity, credibility, number of updates and reminders) mediate intervention efficacy and should be considered when designing interventions.[19,36,38,85] Further, research stemming from multiple disciplines, including social and health psychology, information science, and marketing suggest that factors relating to the individual

(e.g., demographics), the individual's environment (including the online environment), and the intervention itself (e.g., aesthetics, prompts, reminders) are likely to influence how users engage with the intervention and how persuasive it is.[84,86–91] Further research is needed to determine which factors within these domains are most changeable and result in the largest effects when targeted. In line with best practices, these factors should be considered within a conceptual framework that is both evidence-based and guided by theory. Several existing models may be useful for this purpose, including The Elaboration Likelihood Model of Persuasion,[86,88] O'Brien and Tom's conceptual model of user engagement with technology,[87] Short and colleagues' model of user engagement in online interventions,[90] and the Persuasive Systems Design Model,[92] as applied by Kelders and colleagues.[84] These models can be integrated with traditional behavior change theories to form an integrated approach in order to address both sets of determinants – that is, those that predict behavior (e.g., self-efficacy), and those that influence how engaging the intervention is (e.g., use of prompts, reminders, tunneling, social networking features, tailoring).

While some progress in this areas has been made,[84] more research is required in order to develop a more comprehensive understanding of how e- & mHealth interventions work, and how to make them more effective. Particularly, experimental studies examining the impact of specific intervention features on user engagement are an essential next step for theory development and evaluation and thus for building 'a science of user engagement.[91]

Methodological Issues in e- & mHealth Research

A large number of randomized controlled trials (RCTs) of e- & mHealth interventions have been undertaken in the past 10-15 years, and their reporting typically shares common weaknesses. Publications commonly describe the scientific procedure at length, but only provide brief details of the intervention itself. The intervention is typically described by

naming a guiding behavior change theory (if one has been used) and briefly listing a range of characteristics, such as duration and key aspects of content (educational materials, goal-setting, coaching etc.). Eysenbach[93] highlighted the need for detailed intervention description in his development of the eHealth CONSORT guidelines; these reporting guidelines have subsequently been adopted by the Journal of Medical Internet Research, but not by other leading scholarly journals in the field. Similarly, other fields, such as online marketing, are highly mindful of the importance of an e- or m-resource's look, brand and language-style, in how materials are received and used,[94] yet such elements are rarely described in scientific e- & mHealth publications. This is remarkable, given that, by convention, scientific studies should be described in adequate detail to allow reproduction.[93,95]

Maher et al.[25] conducted a systematic review of online social networking behavior change interventions and reported that out of the 10 included studies, only two of the interventions could be publically accessed via the Internet (the rest had either been removed or were locked away behind secure screens so that only research participants with log in details could gain access). In other fields, such as commercial product research and development, viewing, dissecting and learning from others' products is a vital part of developing new products;[96] as such, the inability to view others' e- & mHealth interventions is likely to be severely restricting the development of innovative and improved online health behavior change resources. Online forums and resource sharing websites such Open Science Framework[97] are beginning to address this deficit, offering researchers a public forum through which they can share their resources, and thus allow other researchers to find, use and cite them. Widespread use of such resources will avoid researchers reinventing something that already exists and assist the field to develop more rapidly.

To date, most empirical studies in the field of e- & mHealth (and particularly those published in highly regarded journals) have taken the form of RCTs. Such evidence has been critical for

bringing the field to where it is today, by drawing attention and credibility to the vast potential of e- & mHealth, and providing a body of evidence regarding efficacy. However, RCTs are insufficient to answer several important questions, such as how to disseminate an effective e- or mHealth resource, or assessing whether an e- or mHealth intervention with proven efficacy in a RCT, continues to be effective in a "real-world" setting.[98] One successful example of a "real-world" (sometimes termed "ecological" or "pragmatic") study is Cobb and Poirier's[97] evaluation of a commercial eHealth intervention, "Daily Challenge". Participants were recruited entirely via *Facebook* advertising, minimal exclusion criteria were applied, and participants were free to use the intervention as they chose. The study recruited 1503 participants in just 49 days, shedding light on dissemination strategies, as well as leading to timely production of study outcomes and intervention iterations. Despite such benefits, in our experience, "real-world" study designs are not favored by funders nor publishers compared with randomized controlled designs. Accepting and appreciating the value of ecologically-valid research designs will require a paradigm shift from peer-reviewers, including in many cases, those from within the e- & mHealth field itself.[99]

While there have been significant technological advances in the way dietary data are collected and processed,[100] these advances have allowed researchers to trade one set of issues for another. Limitations of traditional self-report methods of dietary intake include social desirability of response, reporting biases, participant burden, and the dual requirements of literacy and motivation. However, technology-based approaches to data capture (e.g., food photography, computer-assisted recall) create new challenges (e.g., the need for a specific make/model of a device, consistent and speedy Internet connectivity), without reducing the limitations of the traditional approaches. Thus far, new methods have not demonstrated to be superior over traditional "paper/pencil" approaches.[44,100] Therefore, there is an ongoing need for significant methodological e- & mHealth based advances in dietary assessment.

RECOMMENDATIONS FOR FUTURE BEHAVIORAL E- & MHEALTH RESEARCH

Based on the literature presented in the previous sections, the following recommendations have been formulated:

- *Enhance interactivity:* Studies have demonstrated repeatedly that the most interactive interventions lead to higher usage and engagement, which then subsequently lead to greater and longer lasting intervention effects.[19,20,22,34] The use of social media and online social networks is especially promising within this context,[25] and may help to reach underserved groups.[76]

- *Examine the effectiveness of specific intervention components in isolation:* Typically, interventions implement a plethora of intervention components (e.g., goal setting, computer-tailoring, social networking) simultaneously, making it impossible to attribute outcomes to specific intervention components. It is important to understand which specific elements of the interventions led to positive behavior change in order to further improve overall intervention effectiveness.[20,21,30] This may be achieved by applying smart study designs that, for example, have multiple intervention arms in which different combinations of intervention components are examined.[91]

- *Increase the level of detail regarding the intervention description in study reporting*: Whilst most quality journals have already adopted CONSORT reporting guidelines, we advocate that further emphasis should be placed on the requirement for authors to provide detailed descriptions of their e- & mHealth interventions. This is important to inform future research efforts, particularly given that many e- & mHealth resources created for research purposes are not publically accessible.

- *Consider the determinants of engagement and persuasion*: While most interventions will apply health behavior change theory, few systematically apply theories from communication and marketing science in order to improve user engagement and persuasion with the intervention. It is not only important to examine which intervention components are effective, but it is also important to consider a theoretical framework that specifically addresses how intervention content should be communicated and presented in an online environment. This is needed to increase the 'stickiness' of an intervention and participants want to come back time and time again.

- *Examine long-term maintenance of behavior change:* While short-term efficacy of e- & mHealth interventions has repeatedly been demonstrated, few e- & mHealth studies have examined long-term maintenance of behavioral outcomes more than six months after the end of the intervention.[19] Evidence of long-term behavior change is needed if this field is to move forwards.[20,21,69] This is related to the need to improve sustained engagement with e- & mHealth interventions, as higher levels of usage have shown to be related to greater behavioral change.

- *Improve external validity:* A review by Blackman and colleagues on the internal and external validity of mHealth PA interventions found that only half of the included studies reported on intervention reach.[46] These findings are mirrored in the dietary literature.[101] Using the CONSORT-EHEALTH checklist[92] to improve on how intervention trials are reported in the literature can be a useful and practical means of enhancing our understanding of the generalizability of e- & mHealth outcomes. Often too little information is available to allow reproducing the study. Tight journal word limits are often the cause, however more journals now publish full-length protocol papers, which may help to circumvent this problem. Moreover, researchers can provide access to their e- & mHealth resources so that they are

accessible for other researchers and practitioners. This 'open access' model will enhance the dissemination of effective interventions.

- *Apply alternative research designs:* Evaluating intervention effectiveness under real life conditions will be essential to advance the field vertically. Alternative research designs (e.g., n-of-1, pre-post, interrupted time-series, quasi experimental studies) should be considered.[40]

- *Research translation:* To truly test the potential of e- & mHealth interventions large-scale implementation studies are needed, whereby the aim is not only to improve behavior, but also to reach as many people as possible. Applying mass-media broadcasting techniques, as well as social and viral marketing strategies, will play an important role in achieving widespread adoption of new interventions.[102]

- *Focus on underserved populations:* A limited amount of e- & mHealth research has specifically targeted underserved populations. It is important to note that some underserved populations may actually be easier to reach using technology-based approaches, for example, people with physical incapacities that limit their access to traditional face-to-face interventions. In the past, access issues may have reduced the usefulness of e- & mHealth interventions for populations with low social capital, such as ethnic minorities, people from low socioeconomic status backgrounds, and those with literacy issues. However, as Internet access and mobile device ownership further increase, the feasibility of technology based interventions for these populations will also be enhanced.[73]

In conclusion, while our report demonstrates that a substantial amount of progress has been made in the field of behavioral e- & mHealth research, large gaps remain that need to be addressed. Many issues relate to how research has been conducted in this area (e.g., poor reporting), while others are specific to e- & mHealth applications (e.g., lack of knowledge of effectiveness of specific e- & mHealth intervention components).

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