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TECHNOLOGY TO ENCOURAGE THE  
ADOPTION OF HEALTH PROMOTING/  
PROTECTING BEHAVIOURS:

A COMPREHENSIVE LITERATURE  
REVIEW

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## ABSTRACT

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EHealth has the potential to facilitate changes in health behaviours with advances in, and increased use of technology. In fact, 83% of Canadians had access to the Internet in 2012, and in 2011 the Smartphone adoption rate was 40% and is growing. This comprehensive literature review aims to determine in what ways, and how successfully is technology being used to encourage the adoption of health promoting/protecting behaviours. In this review, technology encompasses web-based, mobile-based and computer-based eHealth applications.

Published literature (peer reviewed and non-peer reviewed) dated from 2009 to Dec 2013 was sought from three major health databases. Manual searches of bibliographies from relevant systematic/ meta-analytic reviews were also conducted. The search included papers that addressed eHealth interventions which were used to change health behaviours or addressed management of disease only if the focus was on health promotion/prevention and lastly, if the literature addressed the frequency of use of technology for health information by Canadians. Papers were sought from Canada, USA, the UK, Australia, New Zealand and Western Europe. The search initially yielded over 860 papers. After relevancy testing, 97 primary studies exploring eHealth interventions were included in this review.

The literature points to eHealth interventions that used the following features to encourage health behaviour changes: websites, web portals, email, text messaging, goal setting, assessment and monitoring/tracking, tailored feedback, risk assessments, online lessons/courses, live chats, online counseling/motivational interviewing, peer and expert advice, social networking, and discussion boards. A variety of public health issues were addressed such as: diet, nutrition, healthy weights increasing physical activity, smoking cessation, sexual health promotion, immunization uptake, substance use reduction, and general and/or multiple lifestyle issues. Studies mostly targeted adults from the general population, as well as adolescents, college/university students, and adults in workplace settings.

Results indicated that eHealth interventions are feasible in controlled settings. In general, individuals are accepting and open to using technology to monitor and change health behaviours. In terms of effectiveness, results are largely mixed by health topic. Alcohol use reduction/prevention studies and sexual health studies showed mostly positive and significant outcomes, whereas smoking cessation and multiple risk factor studies showed both positive and negative outcomes, depending on the type of intervention. The most promising intervention designs showing mostly positive and significant outcomes were those that included mixed components (e.g. website plus face-to-face support), include tailored components (personalized feedback or advice), and integrated behaviour change theory (e.g. Social Cognitive Theory). Limitations reported were self-reported outcome measures, limited generalizability of results due to small sample sizes, high attrition rates, and loss to follow up. Many studies also showed short term effects (<6 months), but results were lacking in the long term (>6 months).

Given the range of audiences, variations and limitations in the eHealth intervention papers examined, it is difficult to draw concrete conclusions or make strong recommendations. Ehealth interventions appeared to be somewhat effective in supporting behaviour change in the short term and should be further explored. While the digital divide is closing, it still exists, and should be taken into account to ensure equitable program and service delivery. Interventions need to match the audiences being targeted, and should be integrated into the pool of public health interventions.

## EXECUTIVE SUMMARY

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This scoping literature review answers the question: In what ways, and how successfully, is technology being used to encourage the adoption of health promoting/protecting behaviours? The review focused on the application of eHealth technologies where eHealth was defined as: “an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology” (Eysenbach, 2001) (p.1).

Interventions involving telehealth, telemedicine, television or radio, use of electronic health records, gaming or videogames, and personal wearable devices were excluded. EHealth interventions were narrowed to include traditional public health functions. Research questions addressed in this review included:

1. What eHealth technologies are currently being used for the adoption of health promoting or protecting behaviours? Which are being used in Canada?
2. Which target audiences/population groups are being addressed by the eHealth technologies?
3. What health issues (behaviours) are being addressed by these eHealth technologies?
4. How are eHealth technologies being used? Are they used alone or in conjunction with other non eHealth interventions (e.g. email or text messages in addition to in-person counseling)?
5. How successfully are the technologies being used to encourage the adoption of health promoting/protecting behaviours?
6. What recommendations are provided for successful application of e-health technologies to encourage adoption of health promoting/protecting behaviours?

Background data related to Internet use and mobile technologies in Canada is valuable contextual information for this review. Knowing who is using technology and, equally as important, who is not, is needed in order to be sensitive to issues of health equity. Eighty-three percent of Canadians had access to the Internet in 2012 (Statistics Canada, 2013). Although the digital divide is closing it still exists. In 2010, 98% of Canadians had Internet access in the upper income quartile compared to 58% in the lower quartile (Statistics Canada, 2013) and eastern provinces have lower access rates. In 2011, the Smartphone adoption rate was 40%. Of those with handheld computers or Smartphones, 67% and 88% respectively sent text messages (comScore Inc, 2013). Canadians are well connected to potential eHealth technology platforms aimed at health behaviour change.

An initial yield of over 860 papers was narrowed down to a final total of 97 included primary intervention studies once they were checked for relevancy. The majority of studies took place in the US (n=43), followed by The Netherlands (n=11), UK (n=10), Australia (n=9), and Canada (n=7). In addition, two papers involved US and Canada. EHealth interventions encompassed web-based (n=77), mobile-based (n=18), and computer-based applications (n=2). A variety of public health issues were addressed such as: diet, nutrition, and healthy weights, increasing physical activity (PA), smoking cessation, sexual health promotion, immunization uptake, substance use reduction, and risk reduction (cancer and cardiovascular disease). Studies mostly targeted adults from the general population, as well as adolescents, college/university students, parents, and adults in workplace settings. Few papers addressed seniors, a significant and growing population group.

Largely ignored were Francophones and First Nations peoples, with the exception of one paper targeting the Inuit (McShane, Smylie, Hastings, Prince, & Siedule, 2013). This review was limited to English language publications and is, as such, an important limitation.

Specifically in the Canadian context, study interventions (n=9) focused mostly on web/online based (enhanced and/or interactive websites or web portals) programs and one texting intervention. A variety of health topics were addressed among these studies: uptake of vitamin C, alcohol use reduction, smokeless tobacco reduction, increase in PA, increase access to sexual health risk and testing information, general health seeking behaviours, and drug use reduction. Interestingly, over half of these studies targeted adolescents, and young adults.

EHealth interventions use some of the following features to encourage health behaviour changes: Websites, web portals, email, text messaging, goal setting, monitoring/tracking, tailored feedback, risk assessments, online lessons/courses, live chats, online counseling/motivational interviewing, peer and expert advice, and social networking. Incorporating behaviour change theory into intervention design was also a prevalent theme. The most commonly reported theories were Social Cognitive Theory, Theory of Planned Behaviour, and Transtheoretical Model of Behaviour Change.

In terms of feasibility, at least 16 studies reported feasibility outcomes regarding the acceptability of eHealth interventions and many more incorporated this aspect in its discussion. The majority of these studies indicated that individuals are open to and accepting of using technology for the purposes of changing health behaviours, attitudes and beliefs in a positive way. In some cases, certain features of the technology were preferable in order to enhance engagement, such as text messages that are brief, relevant and positive (Gold et al., 2010).

In terms of effectiveness, outcomes varied by intervention design and health topic. Multiple web-based or mixed interventions in school/college environments tended to result in positive outcomes particularly for increasing PA and healthy eating. The use of tailored feedback, personalized goal setting, interactive learning modules, counseling, and social networking were related to positive behavioural changes. Outcomes for reducing sedentary behaviour were less successful. More active use of such websites was related to better outcomes, and enhanced sites with more interactive features were effective in increasing and maintaining PA. Results for web-based alcohol consumption reduction interventions, most using tailoring strategies, indicated mostly positive and significant outcomes. Likewise, web studies addressing sexual health also showed largely positive outcomes and were mainly aimed at adolescents and young adults. Outcomes included increased knowledge about STI testing, services, and risks, and increased intention to get tested and use condoms. Most web-based smoking cessation studies focused on tailored versus non-tailored content or type of technology used. Cessation programs using tailored content were significantly effective in the short term, however two studies found no significant outcomes.

Studies involving mobile health technologies reported mixed outcomes. Short term self-reported smoking cessation outcomes were indicated using motivational text messages, but long term results were not significant. However, when cessation was biochemically confirmed, abstinence significantly increased in the intervention group. In terms of PA, texting interventions can be effective in increasing PA levels among different audiences. Mobile phone applications to self-monitor and improve PA outcomes are effective but one needs to be mindful of the plethora of behaviour change applications available that are not necessarily evidence based in content. Mobile interventions looking at healthy lifestyle/diet interventions varied in their approach and outcomes.

Only two papers addressed computer-based interventions. One found sustained increases in fruit and vegetable intake over time (Mauriello et al., 2010): The other reported increased knowledge of concussions by ice hockey players, but with non-significant results (Echlin et al., 2010).

One of the common threads among all eHealth intervention papers was that studies showing the most positive and significant outcomes, regardless of health topic, were those that included mixed components (e.g. website plus face-to-face support), included tailored components (personalized feedback or advice), and integrated behaviour change theory (e.g. Social Cognitive Theory). Another common aspect was that many studies showed short term effects (<6 months), but results were lacking in the long term (>6 months). Commonly reported research limitations were: recall bias due to self-reported outcome measures rather than using objective measures (e.g. biometrics, accelerometers), limited generalizability of results due to small sample sizes and target sample demographics, high attrition rates, and loss to follow up.

The following are highlights of recommendations made in this review, given the range of target audiences, variations in outcomes and intervention design types, and limitations in the eHealth intervention papers:

- More research is needed to explore eHealth interventions in a Canadian context.
- EHealth interventions should be considered as a complement to workplace health and school programs in relation to PA, healthy eating and sexual health topics.
- The literature supports the use of eHealth interventions to support health promotion and prevention, however protection was less often addressed and requires more study.
- Designers of eHealth interventions need to consider enhancing web-based interventions with a mix of multiple strategies which should include tailored content.
- EHealth applications should continue to apply behaviour change theory in their design.
- MHealth interventions that include text messaging have shown the most promise for increasing PA and smoking cessation and should be considered in the mix of public health interventions.
- EHealth applications need to be carefully matched to the target audience, taking into account access to hardware (cell phones), the Internet and/or data plans.
- Longer-term studies are recommended to explore characteristics of sustained outcomes.
- The Public Health Agency is well positioned to provide funding for public health eHealth initiatives which can overcome equity barriers.
- Partnerships with public agencies and organizations (libraries, community agencies, schools) are needed to provide access to capacity building around eHealth.
- Diverse populations need to be engaged in design of e-tools, and e-tools should be targeted to them while being culturally appropriate.

In conclusion, this review provides a solid overview of eHealth interventions which have been used for health promoting and protecting behaviours and their effectiveness for public health.

Recommendations should be used with caution given the lack of assessment of methodological rigor in the review. However, integration of our results and conclusions with others reported in multiple systematic reviews and meta-analyses strengthens the suggested recommendations provided. There is room for careful application of eHealth interventions in public health in Canada with attention needed to address health equity challenges. There is also a dire need to support further eHealth intervention research in the Canadian context.

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## INTRODUCTION

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The purpose of this comprehensive literature review is to answer the following question: In what ways, and how successfully, is technology being used to encourage the adoption of health promoting/protecting behaviours? The search was focused on the application of eHealth technologies. eHealth is defined as follows:

EHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.(Eysenbach, 2001)

This comprehensive review includes technologies that apply web-based, mhealth (mobile health such as cellular phones) or computer-based applications. We have excluded applications involving telehealth, telemedicine, television or radio, the use of electronic health records, gaming or videogames, and personal wearable devices. Further, we have narrowed the application of health promotion and prevention to include traditional public health interventions and excluded interventions conducted in primary care settings to keep the search manageable. Also, we have excluded papers focused on disease management.

**Research questions** that will be addressed in this review include:

1. What e-health technologies are currently being used for the adoption of health promoting or protecting behaviours? Which are being used in Canada?
2. Which target audiences/population groups are being addressed by the e-health technologies?
3. What health issues (behaviours) are being addressed by these e-health technologies?
4. How are e-health technologies being used? Are they used alone or in conjunction with other non e-health interventions (e.g. email or text messages in addition to in person counselling)?
5. How successfully are the technologies being used to encourage the adoption of health promoting/protecting behaviours?
6. What recommendations are provided for successful application of e-health technologies to encourage adoption of health promoting/protecting behaviours?

## BACKGROUND

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In 2012, 83% of the total population had internet access compared to 79% in 2010 (Statistics Canada, 2013). In 2012, access was highest in western provinces with BC and AB having the highest rates (88%), followed by ON (84%) and the lowest rates in the eastern provinces (PEI = 77% penetration rate and New Brunswick = 79%). In 2010, Internet access was 97% of households in the top income quartile (incomes of \$87,000 or more) and 54% of households in the lowest quartile, (incomes of \$30,000 or less), a gap of 43%. In 2012, this gap was reduced slightly to 40% with rates in the top and lowest income quartiles being 98% and 58%, respectively (Statistics Canada, 2013). The fastest-growing demographic of Web usage in Canada was shown to be 55 + yrs. of age (comScore Inc, 2013).

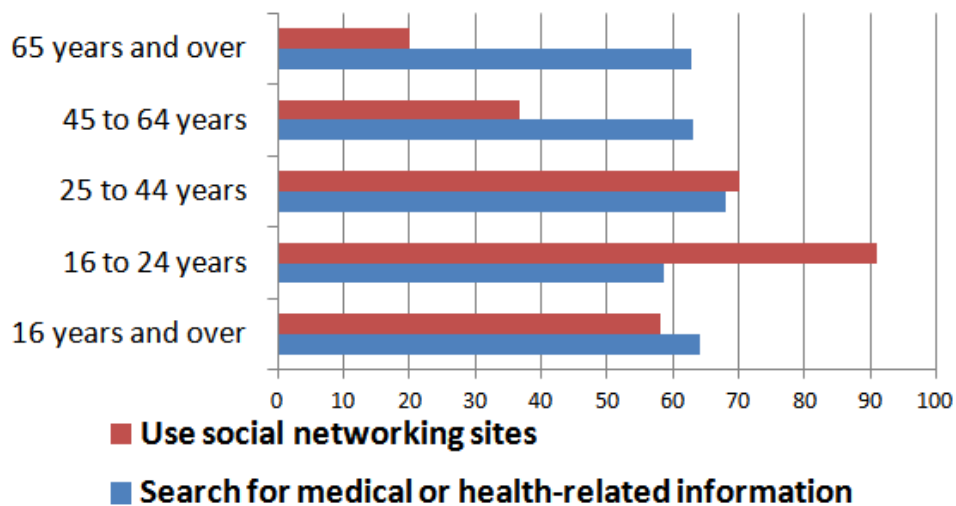


Canada continues to be a leader in online engagement, with the average Canadian spending more than 41 hours per month online on a desktop computer, representing the second highest engagement across the globe (comScore Inc, 2013). This was a slight drop from 43.5 hours a month in 2011. The decrease is likely attributed to increased cell phone use by younger Canadians. Web users aged 17 or under dropped 4 per cent between 2009-2010 (comScore Inc, 2013). Canadians also ranked first in the world in terms of monthly pages and visits per visitor. Email was used by 93% of all Internet users in 2010 (McConnaughey, Neogi, Goldberg, & Brocca, 2013).

Social media was also heavily used by Canadians: Social media players are increasing their visitor base and level of engagement. Although Facebook is in a strong lead, Twitter, LinkedIn, Tumblr, Pinterest and Instagram also show strong visitor growth rates (comScore Inc, 2013). A majority of Canadian Internet users (58%) used social networking sites: 86% of them were under 35 yrs. of age, and 62% were female compared to 54% of males (McConnaughey et al., 2013).

The number of cell phone users in Canada rose from 100,000 in 1987 to more than 24 million by the end of 2010 (Government of Canada, 2012). In 2011, Smartphone adoption reached 40 percent in Canada (ComScore Inc, 2011). Also, as of 2011, of all subscribers to mobile devices (handheld computers) or Smartphone subscribers, 67.4% and 88.1% sent text messages, and 39.5% and 79.3%, respectively, accessed news and information (comScore Inc, 2013).

## CANADIANS' USE OF THE INTERNET TO SEARCH FOR HEALTH INFORMATION



Source: Statistics Canada. Table 358-0153 - Canadian Internet use survey, Internet use, by age group and Internet activity, occasional (percent), CANSIM (database).

**Figure 1. Canadian Internet use survey, Internet use, by age group and Internet activity (%); Adapted from CANSIM table [358-0153](#) (2010)**

Figure 1 illustrates the percentage of Canadians 16 years of age or over who were users of social networking sites or used the Internet to search for medical or health-related information by age (Statistics Canada, 2010). Social networking use was highest among 16- 24 and 25-44 year old Canadians. Over 60 percent of Canadians in all age groups, other than 16 to 26 year olds, searched for medical or health information online.

## SEARCH STRATEGY

Table 1 and 2 outline the inclusion and exclusion criteria for the literature review. Numerous strategies were used to search for relevant literature. These are illustrated with their respective yields in Figure 2. **Databases** that were searched included Medline, CINHALL and Embase using the search terms listed in Table 3. Terms were identified with the assistance of a reference librarian at McMaster University.

<b>Table 1: Inclusion Criteria</b>	
<p>Papers were included that were:                      Published between 2009 and Nov. 1 2013</p> <p>AND                      were published in English</p> <p>AND                      were from Canada, the US, the UK, Australia, New Zealand, and Western Europe</p> <p>AND                      were grey literature, peer-reviewed or non-peer reviewed published literature</p> <p>AND                      addressed E-health interventions used to change health behaviours related to health promoting/protecting behaviours. For example, papers that addressed screening as healthy eating, physical activity (PA), STI prevention, chronic disease prevention, cancer screening,</p> <p>AND                      and addressed populations, individuals and/or families.</p>	<p>OR                      Addressed management of disease (obesity, diabetes) <u>ONLY</u> if the focus was on health promotion/ prevention.</p> <p>OR                      Addressed the frequency of use of technology for health issues by Canadians. These papers include the use of technology to search for prevention/ promotion/ protection information (such as smoking cessation, STI prevention, healthy eating, etc.) or papers related to general health seeking information. This provides further information about who is using technology in Canada.</p>
<b>Table 2: Exclusion Criteria</b>	
<p>Papers were excluded if they addressed:</p> <ol style="list-style-type: none"> <li>1. Tele-health or tele-medicine interventions, since they are typically focused on the management of illness.</li> <li>2. Online social support groups unless the focus was mainly on behaviour change</li> <li>3. Gaming or Video-games</li> <li>4. Wearable technology as a health promotion/prevention strategy unless it was used to collect outcome data (pedometers, accelerometers)</li> <li>5. Television or radio interventions</li> <li>6. Theory related to e-health – i.e., papers focused on what could work 'in theory'.</li> <li>7. The quality of health information on the internet (content analyses) where the content related to topics other than changing health behaviours (health promotion / prevention/ protection) e.g., management of disease (cancer, diabetes, rare disease conditions) or the</li> </ol>	

content was not typically accessed by Canadians e.g., European health information websites.  
 Or papers were:  
 1. Conference papers posters or abstracts, theses, books or book chapters, editorials, commentaries, newspapers, newsletters, or letters to the editor.

**Table 3: Search terms used for database searches**

E-Health terms		Terms for the concepts of promotion prevention and behaviour	
blogging cellular phone computers, handheld device* e?health internet messag*	mhealth mobile mobile device* social media text text messag* twitter youtube	behavio?r behavio?r change change health health behavior health promotion	life style prevention promotion protection public health

**A manual search** was also conducted of 153 papers that cited a highly relevant systematic review and meta-analysis published by Webb (2010) in 2010 entitled: Using the Internet to Promote Health Behavior Change: A Systematic Review and Meta-analysis of the Impact of Theoretical Basis, Use of Behavior Change Techniques, and Mode of Delivery on Efficacy. These are listed at <http://www.jmir.org/article/citations/1376>.

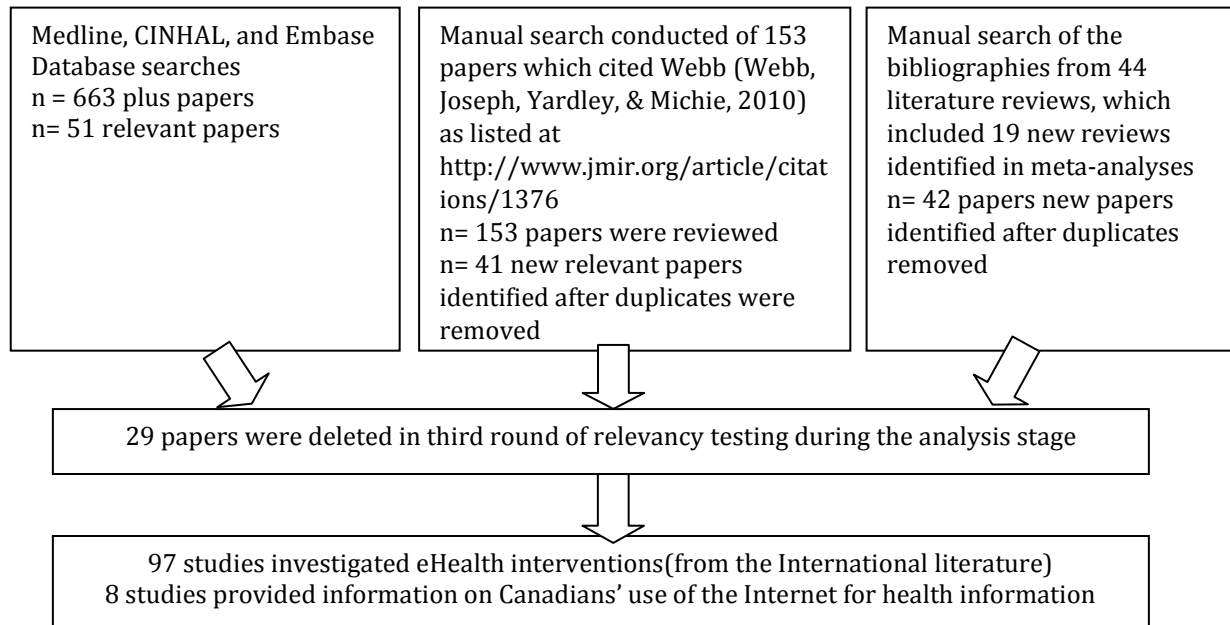
**Reviews of bibliographies** for literature reviews (n=42) which were relevant to this topic were also scanned which included systematic reviews, comprehensive reviews, metanalyses, a Cochrane review, and literature reviews.

**Relevancy Testing:** All papers were reviewed by one research team member in the first round of relevancy review, a second team member reviewed each paper again for relevance where questions or discrepancies arose, and the lead author reviewed all questionable papers where consensus was not reached. All researchers were instructed to be conservative and include papers when they were unsure. Notes were kept in a separate file to highlight questions or concerns to aid in the second relevancy review. Papers were grouped into categories as follows: 1. eHealth intervention research; 2. literature reviews; or; 3. papers describing users or use of eHealth technologies. Literature reviews were only included to assist in locating primary studies and to support discussion and recommendations and papers reporting on use or users of the Internet by Canadians was used to set the Canadian context. Appendix A provides summaries from the e-health intervention studies. Extractions are taken directly from the papers with no interpretation or quality rating conducted as it was beyond the scope of this work. Study limitations, as identified by authors, were noted.

## RESULTS

The final yield of 97 included papers (Figure 2) explored the effectiveness of eHealth technologies on adopting health promoting/protecting behaviours. The majority were from the US (n=43), followed by The Netherlands (n=11), the UK (n=10), Australia (n=9), and Canada (n=7)(Table 4). In addition, two papers involved US and Canada. In addition 8 papers provided information on use of the eHealth, namely using the Internet to search for health information by Canadians.

**Figure 2: Yield from the Search**



**Table: 4: Intervention Papers by Year of Publication and Country of Origin**

Publication Year	# papers	Country	# papers
2009	17	USA	43
2010	18	Netherlands	11
2011	20	UK	10
2012	21	Australia	9
2013	20	Canada	7
2014	1	USA and Canada	2
		New Zealand	2
		Belgium	2
		Mexico /Spain	2
		Various European cities/countries	2
		Denmark	1
		Germany	1
		Norway	1
		Finland	1
		International	1
		Switzerland	1
		Not specified	1

Using technology to access or search for health information was explored by a number of authors. There are variations on how and when health information is most often searched, accessibility of health information, and personal preferences in how to access health information.

Harr and Bella (2010) explored Canadians' challenges in searching for health information on the Internet. The Canadian Health Network communicated high quality trusted health promotion, disease and injury prevention information in the past, but the government site was closed in 2008 and visitors were redirected to the Public Health Agency of Canada's website. Harr and Bella entered the term "health" in google.ca, which yielded 1.29 billion results (February 2009) and 1.13

billion a year later. Using Google and Yahoo search engines, Health Canada's site appeared on the first page among commercial and not-for-profit sites. Not all provincial/territorial government sites had such positive results. In 2010, only Saskatchewan's health portal appeared on Google.ca's first page; Nova Scotia and Manitoba portals were on page 2, British Columbia's site was on p. 3, and New Brunswick's on p. 4. Searches for common health concerns on these government sponsored sites did not produce useful answers written for the lay public.

A study investigating Google searches related to sedentary behaviour, overweight/obesity and smoking was conducted to quantify the frequency and timing that Canadians searched for health information related to modifiable cancer prevention-related behavioural risk factors (Richardson, Hamadani, & Gotay, 2013). Searches conducted between July, 2010 and May, 2011 were examined. The terms "physical activity/exercise" were used most often, followed by "healthy eating / weight loss" and "quit smoking." Most searches were conducted during January which was supported by a Google Insight search (Google search service which examines search terms people enter into Google by country and region). Authors suggested that this may be related to New Year's resolutions.

Two Canadian studies explored searching health information on the Internet. A survey conducted in a large city and surrounding areas in Western Canada involved parents/guardians of children under 6 yrs. of age, who brought their child for immunization between 2007 and 2008 (Devolin et al., 2013). Respondents were mostly white, female, married and well educated (RR 33.7%, n= 359). Parents mostly preferred the Internet as a mode of delivery for parenting information (55.3%), followed by drop-in programs (42.9%), parenting books/ manual (31.7%), organized playgroups (31.4%), and parenting classes/information sessions (31.4%). Fewer than 5% preferred television or radio. Similarly, in a survey of University of Toronto students by Kwan et al., (2010)(n= 1202: RR 24%) in 2006 using the National College Health Assessment showed that the Internet was the most common source of health information (79%) followed by friends and parents. Of those who reported receiving health information from the Internet, PA and fitness (26%) and sexual assault prevention (26%) were most frequently searched followed by sexually transmitted diseases (21%), alcohol and drug prevention (20%), and dietary/nutritional behaviors (17%).

Kanter (2009) from the Wellesley Institute in Canada identified many barriers to effective use of web-tools for health promotion and self-management. Although the authors argued that e-health tools can help address equity issues experienced by traditionally underserved populations, many barriers still exist. They range from lack of physical access (the digital divide), lack of meaningful access ("information designed to reach and appeal to diverse populations" p. 11), language abilities, literacy skills [including traditional, information, media, health, computer, and scientific literacy (Norman & Skinner, 2006)], age, disability and cultural relevance of e-health tools.

Two Canadian studies explored the use of technology for health by various cultural groups. A survey of sources of health information was completed by 899 Chinese immigrants living in Vancouver and Seattle (RR= 59%)(Woodall et al., 2009). More than half of participants in each city used Chinese language newspapers, Chinese language television, friends, and doctors and nurses for health information, compared to 27% and 30% of Seattle and Vancouver residents respectively, who used the Internet. A participatory action research project was conducted involving urban Inuit in the Ottawa area (McShane et al., 2013). A CD-Rom was developed that provided health information using the oral communication tradition and elders from the North to deliver culturally appropriate health messages. Although levels of interest prior to CD-Rom use were mixed (some users showed interest, were cautious or thought they would use the CD-Rom under certain

conditions), after use, users were satisfied and acceptability of the tool was high. Although behaviour change was not tested, the CD=Rom format was acceptable to the Urban Inuit population.

A study of visitors to two large Canadian Web-assisted tobacco interventions [WATI- Canadian Cancer Society's Smokers' Helpline Online (CCS)] and a privately run free program [Stop SmokingCenter.Net (SSC)] provided insight into demographics of "superusers" who took leadership roles on these sites (van Mierlo, Voci, Lee, Fournier, & Selby, 2012). Networking sites aim to promote behaviour change by providing social support. Active discussions were found around one or more active users. There were no differences in demographics of "superusers" who posted 34.78% (CCS) and 46.22% (SSC) of all content, and they made up only 0.4% and 1.1% of total program registrants respectively. The impact of 'superusers' was not studied.

**Summary:** Results indicate that 'one size does not fit all' in terms of using technology as a health communication strategy to promote behaviour change. Students and young parents prefer seeking health information on the Internet: Chinese immigrants do not. To address health equity concerns, applications of e-health need to consider: lack of physical access to technology; lack of meaningful access (information designed to reach and appeal to diverse populations); language abilities, literacy skills [traditional, information, media, health, computer, and scientific literacy (Norman & Skinner, 2006)]; age, disability and cultural relevance of tools. There is a need to deliver information in culturally acceptable formats; increase skills in delivering 'accessible' health information; and engage social media superusers and trusted people (e.g., elders) to support the delivery of health information.

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## E-HEALTH INTERVENTIONS AND THEIR EFFECTIVENESS

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This comprehensive literature review examines eHealth interventions where e-health was the main focus of the intervention or was a complement or addition to other non-e-health interventions (face to face, telephone). Both are presented under the following sections: 1) web-based; 2) mHealth (mobile technologies); or 3) computer-based (stand alone computers without Internet, such as a computer kiosks or CD-Roms). The most frequently studied interventions were web-based, followed by mHealth, and computer-based interventions presented in this order.

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### WEB-BASED INTERVENTIONS

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Web-based interventions accounted for 77 papers included in the review. A large number addressed multiple lifestyle factors, (n=24) whereas others focused on a particular health promotion/ prevention issue. These included: physical activity (PA) (n= 10); healthy eating and/or obesity prevention/management (n= 8); substance use and abuse including tobacco, alcohol, and illicit drug use (n= 18); sexual health (n = 7); reducing risk of disease [e.g., cancer, cardiovascular disease (CVD)] and (n=8), injury prevention (n=1); and, infectious disease prevention (n=1).

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### WEB-BASED INTERVENTIONS ADDRESSING MULTIPLE LIFESTYLE ISSUES

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#### MIDDLE SCHOOL, HIGH SCHOOL AND UNIVERSITY/COLLEGE STUDENTS AND WEB-BASED INTERVENTIONS ADDRESSING MULTIPLE LIFESTYLE ISSUES

Ten studies examined the effects of online interventions with children, youth and adolescents in relation to various lifestyle issues. Three related studies, which were part of The HELENA study

addressed nutrition/healthy eating and PA. Three papers explored web-based e-health interventions related to both PA and healthy eating, three focused on prevention of body weight/fat gain, and one addressed BMI in relation to multiple health behaviours. The first two studies were RCTs and explored interventions addressing both nutrition/healthy eating in conjunction with PA. In addition, a series of three papers, which were part of the HELENA Study in Europe, also addressed PA and healthy eating, although they were reported separately.

DeBar, Dickerson, Clarke, Stevens, Rittenbaugh and Aickin (2009), conducted a 2 year RCT. They reported on user characteristics and usage patterns along with behavioural outcomes of a **multi-component web intervention** in adolescents from the Pacific Northwest. Based on focus groups, the website was seen to be **fun, interactive and engaging**. Use was connected to increased calcium consumption ( $P = .01$ ) and high-impact PA ( $P = .04$ ). Visiting **web pages with behavioral feedback and communications** was not significantly connected to behavioral outcomes. Web pages with **incentives, caption contests, and fun factual information** was frequented most by adolescents.

Cullen, Thompson, Boushey, Konzelmann and Chen (2013) conducted a RCT in Texas to test the impact of a website promoting nutrition and PA for adolescents (**'Teen Choice: Food and Fitness'**). Four hundred and eight adolescents logged onto the intervention or control website weekly for 8 weeks to review web content and **set goals to improve behaviours. The site included role model stories, goal setting, problem solving, and self-monitoring, all features built around social cognitive theory**. Controls set goals but did not have other features. At 8 weeks post test, more intervention group adolescents reported eating three or more daily vegetable servings in the past week compared with controls ( $P < 0.05$ ); both groups reported significant increases in PA ( $P < 0.001$ ) and significant declines in television watching ( $P < 0.01$ ) based on self reports.

In a series of three studies (from The HELENA Study) a school based tailored internet lifestyle intervention was conducted in six centres throughout Europe that explored PA and healthy eating. First, a study led by Haerens (2009) was conducted with 1170 students only in Flemish schools to explore differences in PA between controls (given a page and a half of standard generic advice on PA) and intervention group (**given online tailored advice following completion of a diagnostic tool for moderate and vigorous PA**). After a month, there were no differences found between groups possibly due to contamination from randomization within the schools. De Bourdeaudhuij later led the same team of colleagues to test the above (**Activ-O-Meter**) PA portion of the lifestyle intervention (2010) in six European centres. Further, Maes led the team involving 1298 students across Europe in the **Food-O-Meter** component of the intervention (2011). This consisted of completion of a **food frequency questionnaire, a food composition database and a decision-tree delivering tailored advice to improve intake of fibre, vitamin C, Calcium, iron and fat**. Measurements were completed at baseline, 1 month and 3 months for the intervention and control (received generic standard advice) groups. For the Food-O-Meter intervention, the control group reported statistically significant increases in fat intake while intervention group participants' fat intake did not change ( $F = 54.82$ ,  $P < 0.05$ ). Sub-analysis of normal and overweight students showed a clear positive effect for the overweight group ( $F = 55.76$ ,  $P < 0.05$ ) in reduction of fat intake. An increase in vitamin C was also found in the intervention group [mean intake for intervention group increased from 33-22 (SD 17-42) mg/4184 kJ increased to 38-26 (SD 21-26) mg/4184 kJ (4184 kJ/51000 kcal), compared to controls; 34-22 (SD 18-54) mg/4184 kJ to 31-22 (SD 16-81) mg/4184 kJ ( $F = 4.57$ ,  $P = 0.03$ )]. For the Activ-O-Meter PA component of the intervention, at one month, the intervention group reported higher levels of moderate/vigorous PA by about 20 minutes per week during leisure time and 30 minutes at three months compared to controls whose PA decreased by 20 minutes per week in one month and 20 minutes per week by 3 months (De Bourdeaudhuij et al., 2010). **Tailored feedback was delivered twice by three months** in the intervention group. The

decrease in controls was postulated to be due to participants who were meeting or exceeding recommended PA levels at baseline feeling that they were active enough and could reduce their activity. Results were measured by self-report. Further, there were high dropout rates over time (>50% in month 3) indicating that results should be viewed with caution. Implementation in some contexts was challenging due to research burden, and a lack of motivation by teachers and students.

A RCT (Lubans, Morgan, Callister, & Collins, 2009) investigated effectiveness of the Nutrition and Enjoyable Activity for Teen Girls (NEAT girls) program which consisted of a **multi-component intervention** targeting PA, sedentary behaviour and healthy eating. High school students (n=124) participated in a 10 week sport program involving **exercise booklets, weekly messages, PA and dietary monitoring, pedometer and email support**. The intervention had positive effects on PA and healthy eating, but not on sedentary behaviour. Authors could not isolate effects of program components on outcomes.

The next four studies look at the prevention of weight gain through the modification of multiple lifestyle issues aimed at students in: elementary schools (1), high schools (1), and colleges (2). Williamson et al. (2012) conducted a longitudinal cluster randomized trial in the US to test the efficacy of two school-based programs for prevention of body weight/fat gain compared to a control group, in a sample of over 2000 children (mainly African-American and white/non-Hispanic) from rural areas in Grades 4 to 6. The children were randomly assigned to one of three prevention arms: 1) primary prevention, an **environmental modification to the existing school program** (e.g., cafeteria food service and physical education program), 2) primary plus secondary prevention, the environmental program with an **added classroom and website education component including online counseling and emails to parents**, or 3) non-intervention control. Addition of the classroom/Internet (Secondary Prevention) program to the Primary Prevention program had no significant effects on weight gain, but was connected with better continuance of PA and enrichment of teacher support in the classroom for dietary changes in overweight children.

A study targeting school aged populations assessed the effectiveness of two **theory based**, internet obesity prevention programs on 384 high school students' BMI, health behaviours, and self-efficacy (Whittemore, Jeon, & Grey, 2013). The first intervention group '**HEALTH(e)TEEN**' program involved **multiple online components (goal setting, self-monitoring, health coaching, and social networking; eight highly interactive lessons, and tailored feedback)**, while the second added **four coping skills lessons**. The programs achieved high participation rates. While there were no significant differences between groups on any outcomes or BMI, there were significant improvements in multiple health behaviours [sedentary behaviour, PA, healthy eating, fruit and vegetable (V&G) intake, etc.] and self-efficacy in both groups. A slightly significant decrease in weight was observed (p=0.05) among adolescents. Outcomes were based on self report.

Gow, Trace and Mazzeo (2010) conducted a four arm experiment in the US involving **a) a six session internet intervention (built on social cognitive theory), b) a six week caloric and weight feedback by email, c) a and b interventions combined, and d) no intervention** with 170 healthy first year students aimed at preventing weight gain in their first semester. Discussion boards, experiential learning, participatory activities were encouraged related to healthy eating, exercise and smoking. Based on self-report data, results indicated that BMI scores were significantly improved only in the combined intervention group compared to controls (p <.05).

Another US study (Harvey-Berino, Pope, Gold, Leonard, & Belliveau, 2012) tested the feasibility of an online behavioural weight management intervention for 336 college students. The intervention,



based on social cognitive theory, consisted of **1-hour weekly “group meetings” in an online synchronous chat session led by a behaviour modification expert and online facilitation through achievement of a 45-hour training course and goal setting**. Goals included calorie and fat restriction, healthy eating and increased PA. Moderate weight loss (mean=5lbs) was found for participants with a goal of losing weight. Self reported weight and height measures were used.

**Summary:** Multiple web-based or mixed interventions in school/ college environments tended to result in positive outcomes particularly for increasing PA and healthy eating (increased F&Gs and calcium intake, decreased fat). The use of tailored feedback, personalized goal setting, interactive learning module/s, counselling, and communication through social networking (e.g., chats, discussion boards, email) were related to positive behavioural changes. Outcomes for reducing sedentary behaviour and TV watching were less successful. A common finding among this group of papers was application of theory in the design of interventions, most notably social cognitive theory (7), as well as social learning theory (1), the theory of interactive technology(1), the transtheoretical model of behaviour change (1), and theory of planned behaviour (1)].

### WORKPLACE HEALTH AND WEB-BASED INTERVENTIONS ADDRESSING MULTIPLE LIFESTYLE ISSUES

Six intervention studies sought to change health behaviours in workplaces. Four studies were conducted in the Netherlands, two in the US, and one in Canada. A variety of workplaces were involved. One study involved a large health care organization. The majority investigated their interventions in several workplaces, including: a mix of health care organizations, commercial services, and the executive branch of government; general office settings, IT companies, hospitals, insurance company, a bank head office, and a police force; a mix of 15 undefined workplaces who applied “The Prevention Plan” and five large workplaces in Alberta, Canada.

Two Dutch studies (Robroek, Lindeboom, & Burdorf, 2012; Robroek, Brouwer, Lindeboom, Oenema, & Burdorf, 2010) sought to understand participant characteristics related to the use of a web-based employment behaviour change intervention which included **tailored advice and feedback, self-monitoring tools, and monthly motivational emails**. After baseline assessments and physical health checks, participants were **sent a monthly email to prompt use of the website**. In the first study, 43% of these participants visited the website (Robroek et al., 2010). More female employees visited the site to attain personalized advice and monitor behavior change. Workers with a positive outlook toward increasing PA were less likely to visit or use the self-monitoring web tools. In the second study (Robroek et al., 2012), employees over the age of 30 were more likely to engage in the program and sustain use. In contrast to the first study, employees with low motivation to enhance PA were less likely to engage in the site. Website use was most frequented right after contact activities such as at baseline, after follow-up surveys or receiving emails.

Dekkers et al. (2011) conducted a workplace RCT among overweight Dutch employees to evaluate short and long term impact of a **phone versus Internet lifestyle intervention** on cardiovascular risk factors applied to healthy but overweight workers. Employees (n=276) **were randomized to a phone group, receiving tailored behaviour counselling by phone; an Internet group, receiving tailored behaviour counselling by email; or, usual care**. Based on cognitive behavioral theory, intervention arms consisted of ten educational modules that addressed PA and nutrition and taught lifestyle modification skills. Short term results (at 6 months) revealed a significant favourable effect on total cholesterol level in the phone group and improved aerobic fitness in the Internet group. Long term effects (at 2 yrs.) indicated encouraging trends for body

weight and aerobic fitness in the Internet group. Overall, limited effectiveness among all risk factors was seen. Also, regardless of the intervention (phone or Internet), the more educational modules that participants completed, the stronger the intervention effects were on CV risk factors. The study was limited by voluntary participation, high loss to follow up and more males than females with high education levels limiting external validity.

A recent study by Loeppke, Edington, Bender, and Reynolds conducted a comprehensive workplace intervention to determine impact of **'The Prevention Plan'** aimed at reducing individuals' main health risks over two yrs. (2013). A total of 784 white collar workers participated from multiple US states. The program consisted of an initial health risk assessment plus a variety of tools and services aimed at integrated primary, secondary and tertiary prevention delivered via **24/7 support services, customized health plans, a personalized website which offered participants tutorials, screenings, challenges and other activities** to reducing particular health risks (related to diet, alcohol use, PA, stress, occupational safety, etc.). Researchers defined program engagement into three levels. Statistically significant reductions in health risks occurred with increased engagement ( $p < 0.0001$ ). In the group that engaged through the website alone, 24% reduced their health risks. Long term effects showed that of employees who started in a high risk category at baseline, almost half (46%) moved down to medium risk and 19% moved down to low risk category after 2 yrs. on the program.

Sternfeld et al. conducted an RCT to test the efficacy of a **Lifestyle Intervention Via Email (ALIVE)** among a sample of employees of a large Californian healthcare organization (2009). The goal was to increase consumption of F&Gs and PA, and decrease consumption of fats and sugars. The 4 month program consistent of **tailored email messages sent directly to employees with goal setting, a personal homepage with tips; educational materials; and tracking and simulation tools**. Based on self-reported measures, the intervention group saw an increase of 28.0 min/wk of moderate PA ( $p=0.0002$ ); 12.5 min/wk of vigorous PA ( $p=0.03$ ); and 21.5 min/wk of walking ( $p=0.0003$ ) compared to the control group. Fat consumption was also reduced in the intervention group. Intake of F&Gs increased significantly ( $p=0.03$ ), and consumption of added sugars decreased slightly ( $p=0.08$ ). Four months after the intervention, differences were observed between groups.

A RCT conducted in Amsterdam evaluated the effectiveness of a 3 month workplace (mostly office workers) intervention to increase PA (Slootmaker, Chinapaw, Schuit, Seidell, & Van Mechelen, 2009). The intervention group used **personal activity monitoring (PAM) along with web-based tailored PA advice (PAM Coach)** while the control group received a leaflet on PA. Based on self reported measures, the intervention did not significantly impact PA levels at 8 months follow up.

An Alberta RCT led by Plotnikoff investigated the impact of an email intervention to promote PA and healthy eating (Plotnikoff, Pickering, McCargar, Loucaides, & Hugo, 2010). Of 1590 workers, 1175 were in the experimental group. Controls received **emails with generic PA and healthy eating health messages in bulk (in an email message) at 3 months** while the **experimental group received a set of paired (nutrition plus PA) messages every week**. Based on self-report questionnaires completed a week prior to the intervention, and repeated at 1 week and 6 months after the intervention, bulk email messages had a significant effect on PA and nutrition. Leisure time PA increased for both groups at follow up times, although workplace PA did not change for either group. At 6 months there were no statistically significant differences between groups.

<b>Summary:</b> Most workplace health-based studies tested multi-component interventions that addressed numerous lifestyle issues such as: healthy eating (decreasing fats, added sugars, F&G
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consumption), overweight, increasing PA, managing stress, and increasing occupational safety. Interventions were either focused on two health issues (diet and PA) or they were more comprehensive. They were tested over a 2 year period or were shorter 3 or 4 month interventions. Interventions were delivered in combinations of phone, email and/or personalized web-sites. Tailored emails which were motivational as well as self-monitoring tools were most commonly used as was the provision of counselling and support services in the lengthier and comprehensive interventions. Overall interventions indicated limited effectiveness in modifying risk factors (body composition, PA levels, healthy eating), although most studies showed health behaviour change in a positive direction. The most impactful intervention showed that “leveraging technology with a Web-based health management program with virtual coaching and social engagement are effective health risk reducing alternatives to live coaching interaction.” (Loeppke et al., 2013) p. 263. Visits to a workplace health promotion website increased following contacts such as email or survey. Common limitations of studies included voluntary participation, loss to follow up, and self report.

### THE GENERAL POPULATION AND WEB-BASED INTERVENTIONS ADDRESSING MULTIPLE LIFESTYLE ISSUES

The final section on multiple lifestyle web interventions involved adults from the general population and included five studies from the US, the Netherlands, and Belgium.

Schneider, et al. (2013) studied the reach of an embedded intervention into an existing health monitoring system that was occurring within the public health system in the Netherlands. The aim was to engage more participation in an **Internet-delivered multi component computer tailored intervention** among citizens in two Provinces. Of 96,388 adults who were invited to participate in the Adult Health Monitor, 9169 were interested in participating in the computer tailored intervention and 5198 completed it, with males, older respondents, those with higher education levels, who led a healthy lifestyle and had a healthy BMI were more likely to participate. Modest reach was attained for those at-risk (e.g. low socioeconomic status and unhealthy lifestyle).

Another Dutch study explored the content and timing of an email prompt to increase engagement in an Internet delivered lifestyle intervention among employees in a municipality (Schneider, de Vries, Candel, van de Kar, & van Osch, 2013). In this 2 by 3 RCT design, participants received either a **standard email prompt, or an email with a preview of new content on the lifestyle website, which were delivered after 2, 4 or 6 weeks**. Evidence based interventions were introduced for PA, smoking, alcohol and F&G consumption. Statistically significant differences were seen with respect to timing of emails; 2 week prompts resulted in more visits to the intervention website compared to 4 and 6 week prompts. Enriched content also helped, although differences were not statistically significant.

Next, Wing, Crane, Thomas, Kumar, and Weinberg (2010) conduct a 2-part study to find out whether adding behavioural weight loss strategies could progress the outcomes of a community weight loss campaign called ‘**Shape Up RI**’. The campaign consisted of a 12-week, online, team-based program. In study 1, participants (n=179) were randomly assigned to the standard **Shape Up RI program or to the program in addition to video lessons on weight loss**. In study 2, participants (n=128) were randomly to the standard program or to the program plus **video lessons, and other enhancements such as daily self-monitoring of weight, eating, and exercise, and computer-generated feedback**. Adding video lessons alone (study 1) did not produce significantly improved weight loss (p=.15). Conversely, study 2 results indicated the

average weight loss more than doubled ( $P < .01$ ), and the number of participants obtaining a weight loss of 5% or more tripled ( $p < .01$ ) with additional enhancements added to the standard program.

Jacobs, De Bourdeaudhuij, Thijs, Dendale, & Claes (2011) performed an RCT in Belgium to examine the effects of an intervention on health behaviour (fat intake, physical activity, and smoking) and BMI compared to 'usual care' in a sample of well educated adults. Intervention participants had access to a **tailored website and one-on-one coaching by a psychologist**. Behavior change techniques derived from the **TPB and Self Determination Theory** were used to guide the intervention. Results showed that website use combined with coaching ( $p < .05$ ), and intensive coaching by e-mail and telephone were effective to increase PA ( $p < .01$ ) but no significant outcomes were observed for fat intake. Higher intervention engagement resulted in greater outcomes for fat intake and PA. However, after six months, the program was not more effective than 'usual care' in altering health behaviours and BMI. Self reported measures and the specific target audience of well educated adults limits external validity.

The next two studies examine the outcomes from a theory driven web-based intervention called '**Guide to Health**' taking place in the US. First, Winett et al. (2011) examined the effects of the intervention on PA, F&G consumption, and body weight among a sample of 247 adults (mean age 45.5). Participants were randomized to a basic intervention or an enhanced intervention consisting of **52 weekly social cognitive theory based modules**. Both interventions included **behaviour targetting, goal setting, and strategizing information**. The basic intervention included generic feedback and planning approaches, whereas the enhanced program included tailored feedback and planning. Despite high attrition rates and self-reported outcomes, participants in both interventions increased PA by approximately 1,400 steps/day, lost approx. 3% bodyweight, and increased F&G intake by approx. 1.5 servings/day at follow up. Enhanced intervention participants increased self-efficacy for reducing fat and calorie consumption while basic participants saw a decrease. In the second study, Anderson-Bill and colleagues (2011) examined the impact of '**Guide to Health**' on improving healthy eating and PA for overweight to obese and inactive adults who were otherwise healthy. At 16 months, participants lost close to 3% of their body weight, increased step counts by 24%; increased weekly METS (metabolic equivalent) expended in walking fourfold; reduced daily calorie intake from fat by 2%, sugars by 3%, and total calories by 10%; and increased F&G intake by roughly 1.5 servings per day. Although the study tracked outcomes over a longer period than most studies, generalizability is limited given the predominantly white affluent, female sample.

**Summary:** With regard to web-based interventions aimed at multiple lifestyles for the general public, two Dutch studies explored engagement of citizens on lifestyle websites. One study showed less engagement of citizens from lower socioeconomic groups and less healthy lifestyles indicating a need to explore strategies to increase engagement and address health equity issue. The second paper showed that use of email prompts and enhanced content in emails (previews of new website content) increased visits to health promotion websites. Studies that investigated outcomes of interventions showed that adding enhancements to self-monitoring and tailored websites such as video enhancements, and intensive coaching by email and telephone had more positive results such as increased weight loss, physical activity and lower fat intake. However these results were not consistent or not sustained over time. Two papers exploring the US "Guide to Health" program involving goal setting, targeting behaviours strategic information (based on the social cognitive theory) showed positive outcomes, such as increased PA and improved diets, although generalizability was limited.

## WEB-BASED PHYSICAL ACTIVITY (PA) INTERVENTIONS

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A frequently addressed issue in web-based interventions was PA. Six studies addressed adult populations in the general population and 4 were focused on college/university students.

### ADULTS AND WEB-BASED INTERVENTIONS ADDRESSING PHYSICAL ACTIVITY

Of papers focused on adult populations, most aimed to increase activity of sedentary individuals. One was a descriptive qualitative study and the rest were RCTs, one of which added focus groups. They were conducted in the US, Denmark, Switzerland, and Australia.

A RCT (Carr et al., 2013) tested the efficacy of an enhanced Internet intervention [**Step into Motion**]. It was found to be successful in a previous trial (Marcus, Ciccolo, & Sciamanna, 2009)], to promote PA among sedentary adults against 6 publically available PA websites which were successful in retaining users. Enhanced features of “Step into Motion” included: **interactive logging, self-monitoring, and goal setting tools; a geographic mapping tool; an Ask the Expert discussion forum; exercise videos; and updates from peers on progress, and immediate individually tailored motivational PA messages**. Goals were set to be physically active for 150 minutes per week with moderate intensity. Participants were taught how to measure activity and heart rate. Participants logged onto the enhanced site over 32.2 times in 6 months compared to 9.4 for the standard sites. Outcomes showed that the enhanced site was more effective in increasing PA in the first three months (18.4 to 186.0 min/week vs. 20.9 to 57.3 min/week;  $p = .03$ ), although these differences were not seen at 6 months. Enhanced website participants maintained PA from 3 to 6 months (186.0 to 176.8 min/wk), the standard website users increased PA (57.3 to 133.5 min/wk). PA was measured using self report.

A RCT study from Denmark (Hansen et al., 2012) invited over 12,000 participants nation-wide to participate in web-based PA intervention (43.8% participation rate). They were randomized to a no intervention group or the experimental group. The intervention involved **tailored advice on a personal profile, a discussion forum with replies from a physiotherapist, normative feedback relative to PA recommendations in various areas such as strength training, fitness training and everyday activities**. Seniors over 60 yrs of age received extra strength training advice and could monitor their results and progress in a profile. No significant differences were seen between groups for reports of PA at 3 and 6 months for health examinations. However, more active users of the intervention showed more leisure time PA than low users and a single feedback report was enough to change PA levels (self-reported).

A Swiss RCT tested the effectiveness of a **tailored versus non-tailored web based intervention (Active-Online)** on 1531 participants (mean age 44 yrs. and 75% women) recruited from a German region by various media channels (Wanner, Martin-Diener, Braun-Fahrlander, Bauer, & Martin, 2009). The tailored program offered **counselling and motivational feedback (with email reminders)** compared to a static website with general information on PA. In both groups there was a significant increase in moderate and vigorous PA (self-reported) from baseline to 6 weeks ( $p = .001$ ), although there were no increases in PA seen over time when measured objectively (using accelerometers).

A RCT was conducted to evaluate a standalone 12 week Internet intervention-“Active over 55” – geared for older sedentary adults which assisted users to create their own PA program.(Irvine,

Gelatt, Seeley, Macfarlane, & Gau, 2013) It included **test and video messaging, goal setting activities, and support for users to develop a tailored exercise plan**. The intervention group showed significant improvements on all (e.g., overcoming exercise barriers, minutes of activity per week) but one of 14 outcomes (BMI) at post-test compared to controls based on self-report. Effect size was large at 3 months and moderate at 6 months.

A unique RCT Australian study with focus groups by Ferney et al. (2009) evaluated the effect of a neighbourhood environment-focused website for PA promotion for middle aged adults. One hundred and six mostly women, were randomized to either a **neighbourhood-based site or a motivational information site** and each group received **11 emails over 26 weeks**. Participants self-reported their activity and web site use was monitored. The neighbourhood website was used significantly more often (nearly three times more often) ( $p < 0.01$ ) and more in the first 12 weeks, although use of interactive features was lower than expected. The neighbourhood group had more favourable impressions of the site than the comparison group. It had a **searchable database for PA activities, a calendar of events, a walking trail map, profiles of the suburbs a bulletin board and access to email advice**. Both groups had statistically significant increases in walking and overall PA over time, but the neighbourhood group maintained more of their overall PA activity by week 26 ( $p < 0.05$ ). Results point to benefits from neighbourhood focused PA websites.

A US descriptive study by Lohse, Arnold and Wamboldt (2013) examined responses to **two online lessons in a ten lesson course (About Being Active)** designed originally for college students. The course was repurposed for and with low income women related to increasing PA lifestyles including overcoming barriers to exercise. Overall, the 12 low income predominantly white and Hispanic women in Pennsylvania provided positive feedback and most enjoyed the interactive components (quizzes and activities) and gained new insights which they felt encouraged them to increase PA.

**Summary:** Three studies exploring web-based interventions to address physical activity were geared for the general public, while one each was focused on seniors, middle-aged adults in a neighbourhood, and low-income women. Interventions to increase PA included many of the same features as noted above including: motivational messages and feedback with reminders, self monitoring and goal setting, tailored advice (by a physiotherapist). However, this group of papers also introduced new features in three studies, including the use of walking trail maps, profiles of suburbs, geographic mapping tools, a neighbourhood calendar of events, and a searchable database for PA activities, exercise videos, discussion boards, and online lessons in a course about being active. Effectiveness of interventions was varied in this group of papers. More active use of websites was related to better outcomes and enhanced sites with more interactive features such as “Step into Motion” and the neighbourhood-based website were also more effective in increasing and maintaining PA. Self report of PA was the most common study limitation. Further, one study found that PA reports were not valid against PA measured objectively using accelerometers.

#### COLLEGE/UNIVERSITY STUDENT WEB-BASED INTERVENTIONS ADDRESSING PHYSICAL ACTIVITY

Two quasi experimental studies conducted in Canada and the US, and two RCTs conducted in Scotland and the US make up this group of papers related to PA and college/university students.

The study by Kwan, Faulkner and Bray was conducted involved 65 mostly female ( $n=44$ ) students entering university in Toronto (2013). Students were assigned to a **PA promotion website “Active**

**Transition”** (targeted to change PA cognition and self-regulatory skills) **with or without weekly prompts.** PA behaviours, attitudes and perceived behavioural control declined for the broad population over time. Low response rates, retention and compliance (45% logged on 2 or more times), short length of the intervention, self-report, recall and social desirability bias, and a small sample size were significant study limitations.

A US quasi-experimental pilot study of a convenience sample of 233 students enrolled in three courses was exposed to a different intervention (Grim, Hertz, & Petosa, 2011). Students were allocated to one of three interventions: 1) a **web-based course built on social cognitive theory (including quizzes, lecture materials, assignments involving application of lessons into their daily activities)**, 2) **PA labs and received instruction**, and 3) **in-class PA instruction**. Course participants and those who attended PA labs had significant changes in PA, self-regulation (applied to maintaining PA) and outcome expectancy over time ( $p < .01$ ). However, groups were not randomized, there was poor response to follow up, and outcomes were measured on self-report.

A RCT by Skar and colleagues (Skår, Sniehotta, Molloy, Prestwich, & Araújo-Soares, 2011) involving 1273 out of 13000 mostly female (63.4%) university students in Scotland (average age 22.8 yrs. and BMI 22.5) were recruited to participate in creating various combinations of a) **actions plans and/or b) coping plans designed to address the TPB delivered via the Internet** to increase PA. Interaction effects were not significant for either individual or combined interventions based on self-report of PA and objective measures of attendance at university sports facilities. Low response and high dropout rates limited generalizability.

A 12 week US feasibility RCT of 134 predominantly white, female undergraduate students from well educated families (Cavallo et al., 2012) tested effectiveness of **INSHAPE- a themed website with PA self-monitoring encouraged by emails, a moderator and instructions and invitations to join a social support group on Facebook** compared to a control group. Entry into a draw for gift cards was used to encourage postings. There were no differences seen between groups over time for either outcome; although students were willing to recommend the site to others and reported increases in PA and support over time (Cavallo et al., 2012).

**Summary:** Interventions to increase PA were built on theoretical foundations in three studies. Interventions involved the use of tailored messaging, self-monitoring, and email prompts, with the addition of online courses, internet-based action planning and coping plans, and a social support group on Facebook. Of the four studies in this group, the only intervention that resulted in positive outcomes included a web course built on social cognitive theory. Limitations reported by authors varied including: small sample sizes, short intervention timelines, drop outs, and self-report of PA.

## WEB-BASED HEALTHY EATING AND OBESITY PREVENTION/MANAGEMENT INTERVENTIONS

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### GENERAL POPULATION AND WEB-BASED INTERVENTIONS ADDRESSING HEALTHY EATING

A US and Australian study explored e-health interventions to promote healthy eating using social media and the third involved a 15 week web-based program: All were geared to the general public.

Barragan conducted focus groups and surveys of vulnerable groups in Los Angeles county to co-design a campaign aimed at reducing sugary beverage consumption– The Sugar Pack Campaign (Barragan et al., 2013). **Multimedia was used including paid media communication on billboards, television, videos, plus a website and social media resources.** There were numerous hits on the website (choose-healthla.com) and interactions with social media resources (including Twitter, Facebook, YouTube). Multimedia views included over 15,000 YouTube, 1.5 million Twitter impressions, 63,000 Facebook interactions, and 535,000 website hits. A sugar calculator was also promoted using Facebook and Twitter and received close to 60,000 hits. However, there were no results that indicated an impact on behaviour change.

Brindal and colleagues conducted a mass media promotion to recruit overweight/obese Australian adults to their RCT, which explored retention and weight loss outcomes through the promotion of the Total Wellbeing Diet (TWD) (2012). Three arms of the study included **various combinations of online information including menu plans, recipes, shopping lists, success stories, alcohol management information, quizzes and links, self-monitoring, a weight tracker, and graphical progress in real-time, and/or a social support network. Seven combinations of features fit into three types of interventions: a) information-based, b) supportive, and c) personalized-supportive websites.** At 12 weeks, 23.7% of those who started the intervention lost a clinically relevant amount of their baseline weight (>5%). Those who completed the program (n = 435/8112) on average lost 4.10% (SD 4.05) and 37.6% lost over 5% of their body weight. Of completers, there were no significant differences between groups in weight loss. Use of the weight tracker was the only predictor of weight loss. There were differences in those who completed the program and did not: completers were older females and non-completers had higher proactive coping.

Alexander with colleagues recruited healthy 26 to 65 yrs. olds from administrative databases from 6 health plans in the US (n=2513) who had internet access and read email at least weekly (2010). Participants were randomized to receive a 15 week web untailored program (control), **a web-tailored behavioural intervention or a web tailored behavioural intervention plus motivational interviewing–based counselling provided through e-mail tailored to the participant’s stage of change.** Average F&G servings increased by more than 2 servings in all three groups (P<.001), with the greatest change seen in the latter group (+2.8 servings) (P=.05, compared with control). Program satisfaction was high overall. Volunteer bias and number of drop outs were limitations.

**Summary:** Only one study in this review tested e-health applications in a social marketing campaign. Various social media and web-based visual and video tool use resulted in high uptake by the general public (measured by hits) in messaging around sugary beverages. Two intervention studies aimed at changing dietary habits had mixed results. One study tested various combinations of online features categorized as information-based, supportive, or personalized-supportive, and the other tested a web-tailored behavioural intervention versus motivational interview counselling through email. No differences were seen in outcomes in the three intervention types, and mean weight loss was 4.1% of body weight for program completers. Use of a weight tracker predicted weight loss. The second study was effective in increasing F&G consumption (up more than 2 servings) in all intervention arms, but was most effective in the counselling arm.

## WORKPLACE HEALTH WEB-BASED INTERVENTIONS ADDRESSING HEALTHY EATING

A US feasibility RCT and Australian cross-sectional study aimed at healthy eating or obesity prevention interventions were conducted in workplaces with mixed results. Morgan and colleagues (2011) evaluated the feasibility and efficacy of a workplace intervention (POWER WP) targeted at



110 Australian male shift workers: 45% were considered obese (Mean age- 44 yrs., and mean BMI - 30.5 kg/m<sup>2</sup>). The intervention received **information session, booklets, group-based financial incentives, and an online component**. The men were expected to submit daily eating and exercise **diaries** at different rates over three months. Those who participated received 7 **emails with individualized feedback and strategies to address dietary issues by research staff expert** in health and physical education or nutrition and dietetics. There were statistically significant differences for weight loss and a number of positive outcomes (reduced systolic BP, resting heart rate, BMI, sweetened beverages and PA related cognition) over time favouring the intervention.

A cross sectional study in the US evaluated the long-term effects of a commercially available web-based tailored weight management program involving over 2000 employees, out of over 22,300 eligible employees with BMIs over 25, in a Fortune 500 health care company (McHugh & Suggs, 2012). Following health biometrics testing and online completion of personal information (e.g., family health history, self-efficacy, motivation, attitudes about weight management, diet and PA behaviours and barriers, subjective norms, and social support) participants received **online tailored feedback, which addressed psychological, emotional and behavioural needs**. They could access web content for a year and **monitor their PA and nutrition goals online**. A variety of on-site health resources were also available for employees to meet their health needs. Some results were unexpected: The mean difference in systolic blood pressure and blood glucose increased over time. However, participants lost an average of .34 pounds, and cholesterol and LDL declined over time. The authors reported concerns about small sample size, and hypothesized that employees may have been generally disinterested in the workplace program, lacked confidence with organizational health communication, and/or the promotion of the program was poor.

**Summary:** Two studies of workplace interventions aimed at overweight/obesity workers resulted in mixed outcomes. The most successful was a three month intervention with multiple components including booklets, monetary group incentives, food diaries and email tailored feedback which focused on strategies to address dietary issues. Positive statistically significant outcomes included weight loss, Reduced systolic BP, resting heart rate, BMI, sweetened beverages and PA related cognition McHugh and Suggs' (2012) less successful intervention was longer term (2 yrs.) and used a commercially web-based tailored weight management program with monitoring of PA and nutrition goals, and online tailored messages. Negative outcomes included increases of blood glucose and systolic blood pressure over time, although participants lost .34 pounds and lowered cholesterol and LDL. The authors postulated that workplace organizational factors such as poor program promotion may have been a factor influencing the intervention's success.

#### MIDDLE SCHOOL AND COLLEGE/UNIVERSITY STUDENTS WEB-BASED INTERVENTIONS ADDRESSING HEALTHY EATING

Two studies that explored the use of web-based interventions to explicitly address healthy eating involved college/university students and the third was aimed at middle-school children. All used theory to design the interventions including social cognitive theory and the theory of planned TBD.

A US quasi-experimental study and Australian pre-post design study involved college/university students. Poddar et al (2010) conducted a 5 week online intervention targeting college students' dairy intake. The intervention using **social cognitive theory, included email, posted information, and behaviour checklists with tailored feedback components**. Intervention group participants showed greater increases in self-regulatory strategies and self-efficacy for consuming 3 servings of dairy products per day compared to no-intervention group; however, no changes were

found for **dairy consumption**. An Australian study by Kothe et al. (2012) examined efficacy of an intervention aimed at undergraduate students that was **based on TPB** to increase F&V consumption. The intervention included **low frequency versus high frequency email messages encouraging F&V intake**. Across both groups, F&V intake increased by 0.83 servings/day, however no differences were found between email frequency groups.

A US study aimed at middle school teens investigated the use of a **brief (1-2 week) web-based intervention - Health Outcomes for Teens (HOT)** [including TPB constructs including behavioral belief, attitude, subjective norm, perceived behavioral control, knowledge and behavioral intention](Muzaffar, Chapman-Novakofski, Castelli, & Scherer, 2014). It compared **active [videos (observational learning), narrated text (social persuasion), and knowledge/skill based games (knowledge and behavioral control)] and passive (text and images with minimal interactivity)]** online learning aimed at changing behaviours of middle school children to prevent obesity and type 2 diabetes. There were no significant differences between passive and active sites except for behavioral belief. HOT improved knowledge and TPB constructs scores for targeted behaviors, PA and healthy eating.

**Summary:** The TPB or social cognitive theory was applied in each of the three studies which addressed healthy eating in student-centred web-based programs. The studies aimed at college level students focused on increasing dairy or F&G intake, and the middle school intervention aimed to reduce obesity and type 2 diabetes. The interventions tested: a) encouraging emails sent with varying frequency, b) posted information, and behaviour checklists with tailored feedback components against a no intervention control, and c) more and less active interventions (active videos, narrated text, and games versus passive text and images). No significant differences were seen in interventions and controls except for behavioural beliefs around healthy eating and self-efficacy related to increasing dairy. F&G consumption increased with encouraging emails.

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## WEB-BASED SUBSTANCE USE AND ABUSE INTERVENTIONS

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### SMOKING CESSATION

Thirteen papers examined the use of the web as a smoking cessation intervention. All studies with the exception of one (Danaher et al., 2013) focused on adults. Eleven of 13 studies were RCTs except for a paper by Abrams et al. (2012) and an uncontrolled pilot study by Brown et al. (2012). Six of the studies aimed at determining whether interventions that provided smokers with **tailored content** was more effective for smoking cessation than content that was not tailored. Four studies examined the effectiveness of the **type of technology used for smoking cessation programming** (e.g. internet, phone, internet + phone). Three studies focused on feasibility or acceptability while one focused on understandability, credibility and personal relevance of interventions using technology. Over half of the studies applied behaviour change theories or models.

For studies that examined **tailored content and type of technology**, participant average age was between 36 and 49 yrs. of age with the exception of the one study that focused on young (mean age 20.8) smokeless tobacco chewers (Danaher et al., 2013). Most were recruited through multiple means including, news, radio, TV, internet, magazines, purchased email lists, etc. Four of these studies recruited participants via search engines and visits to intervention websites (Graham et al., 2011; Mason, Gilbert, & Sutton, 2012). Eligibility criteria generally included participants who were considered daily smokers (smoking X amount of cigarettes per day), were motivated to quit within

a set timeline, and had access to internet or personal cell phones. All of the studies used self-reported smoking abstinence at particular time points except Elfeddali et al. (2012) who exercised biochemical validation of smoking cessation among its participants at 12 months follow up.

Three studies that focused on **acceptability** of the smoking cessation program focused on a different target population [undergraduate students (Abroms et al., 2012), pregnant smokers (Naughton, Prevost, Gilbert, & Sutton, 2012) and adult smokers (Brown et al., 2012)]. Two of the studies tended to have younger participants (26-30 yrs. of age) and different means of recruitment (university flyers, list serves and recruitment through midwives).

Four of the six studies that investigated **tailored versus non-tailored programs** showed that tailored content was significantly more effective than non-tailored programs for short term smoking abstinence (Mason et al., 2012; Elfeddali et al., 2012; Wangberg, Nilsen, Antypas, & Gram, 2011; Smit, de Vries, & Hoving, 2012). However, intervention effects were not seen long-term (6 -12 months) (Wangberg et al., 2011; Smit et al., 2012). One of the studies suggested a dose response relationship between adherence to the program, often due to the number of program elements (e.g. tailored feedback + assignments, multiple follow ups) and smoking abstinence (Smit et al., 2012). Two studies found no effect regarding tailored versus non-tailored programs on smoking cessation outcomes (Danaher et al., 2013; Mason et al., 2012).

Of the studies that looked at **type of technology/strategy** on smoking cessation, the results were mixed. Interventions that used multiple technologies (e.g. phone + Internet) had stronger effects on abstinence rates compared to programs using one type of technology (Graham et al., 2011; Zbikowski et al., 2011; Borland, Balmford, & Benda, 2012). Also, for programs with **phone and internet components**, participants preferred phone counseling compared to internet/websites (Zbikowski et al., 2011). Borland, Balmford & Benda (2012) looked at the impact of online versus text versus combined strategies on smoking cessation rates and while the combined intervention effects were greater than the control group, results were not significant. Muñoz et al. (2009) looked at an evidence based pamphlet versus the added effect of an email vs. the added effect of mood management lessons vs. the added effect of a virtual support group and found no significant differences on cessation outcomes between the different strategies used.

Studies focusing on **acceptability** of interventions by users showed that using technology in a smoking cessation program is feasible, acceptable and satisfactory for their target audiences (pregnant smokers, university students, and adults). Intervention participants in the Te Poel et al. (2009) study indicated appreciating the computer-tailored e-mail program significantly more with respect to understandability, credibility and personal relevance than the control group. However, abstinence rates were either not statistically significant between groups (Naughton et al., 2012), or participants stopped responding to follow-ups post quit-date (Abroms et al., 2012). Brown et al. (2012) examined if acceptability was affected by socioeconomic variables: No significant results were found implying that outcomes were equally distributed across the social continuum.

**Summary:** The majority of web-based smoking cessation studies either focused on tailored versus non-tailored content or type of technology used in terms of efficacy in changing smoking behaviours. Of these ten studies, only one (Elfeddali et al., 2012) biochemically validated cessation (with positive outcomes). The rest relied on self-reports. Outcomes were mixed in terms of effectiveness. Tailored content cessation programs were significantly effective in the short term, however two of six studies found no significant long-term outcomes. Likewise, interventions using different and/or combined strategies (e.g. two types of technology or technology plus non-

technology strategies) showed both significant and non-significant results. Overall, participants are accepting of technology interventions to cease smoking behaviours.

### ALCOHOL USE REDUCTION/PREVENTION

Four studies looked at web-based interventions related alcohol consumption reductions or alcohol use prevention. Three of four studies used tailoring strategies in their intervention while two studies were rooted in behaviour change theories explicitly and one included cognitive behavioural components. All interventions showed at least one positive and significant outcome.

Conducting a pilot feasibility study, Mauriello, Gkbayrak, Van Marter, Paiva, & Prochaska (2011) used a **computer tailored intervention (“Responsible Drinking”)** for adults who surpassed the recommended guidelines for low-risk drinking. Rooted in Transtheoretical Model constructs, the intervention offered assessments with tailored feedback, behavioural guidance and strategies, and an interactive website offering activities. Although a small and homogeneous sample was used, significant outcomes were reported in terms of reduced intentions to drink.

The remaining studies were RCTs aimed at adults (Schulz et al., 2013; Cunningham, 2012) and an intervention/control design (**“M-PASS”**) aimed at college students (Bingham et al., 2010). Starting with Bingham and colleagues (2010), college students received **four 10-15 minute interactive online sessions tailored to each participant’s alcohol related risk**. The sessions were rooted in four behaviour change theories. Interestingly, only one significant effect was found for male and female students (more advanced stage of change compared to controls), whereas remaining intervention effects were significant for female students only when compared to controls (significantly lower tolerance of drinking and more strategies to avoid at risk drinking).

A Canadian study by Cunningham (2012) evaluated whether providing access to an **extended Internet intervention with cognitive behavioural, motivational and relapse prevention components** offered added benefits in promoting reductions in alcohol consumption compared with a brief Internet screening intervention. Relying on self reported measures and no control group, the study showed a significantly greater reduction in drinking levels among participants in the extended intervention group compared to the brief intervention group ( $p=0.046$ ).

Lastly, a German paper by Schulz, Reinwand, Candel, Kremers, Reinwand, Jander and de Vries (2013) assessed the effectiveness of a **3-session, web-based tailored intervention** in reducing alcohol intake in high-risk adult drinkers using two different tailored feedback strategies (alternating and summative). The results indicated there were no differences in the type of feedback strategies. In the experimental group, 21.1% of respondents conformed to drinking guidelines after 6 months compared with 5.8% in the control group ( $p = .02$ ). In addition, the experimental group reduced alcohol consumption by 3.9 drinks per week compared to 0.4 drinks per week in the control group, however, statistical significance was not achieved ( $p = .05$ ).

**Summary:** Results for web-based alcohol consumption reduction interventions indicated mostly positive and significant outcomes. Studies varied in design type (RCTs, pilot, and intervention/control) but were similar in that most used tailoring strategies and the application of behaviour change theories/principles. Web based interventions reduced alcohol consumption levels as well as intentions to consume alcohol among all participants, lowered drinking tolerance and enabled more strategies to avoid at-risk drinking among female participants. One study compared various feedback strategies with no differences in outcomes; improvements were seen for alcohol intake

reductions in the experimental groups.

### MULTIPLE SUBSTANCE USE PREVENTION

One study by Schwinn, Schinke, & Di Noia (2010), focusing on female adolescents in the US and Canada, created and tested an Internet-based multiple substance abuse prevention program. Recruited through a youth website, female participants (mean age 14 yrs.) engaged in a **12-session, Social Learning Theory guided program that included components such as goal setting, decision making, coping, communication and self-esteem skills**. At one month reporting, there was no indication of differences between intervention and control group. However, at 6-month follow-up, between group differences were found on measures of 30-day alcohol use, marijuana use, multiple drug use, and total substance use where the intervention group reported lower usage rates. Generalizability was limited to computer literate, motivated female adolescents.

**Summary:** With only one study found in the multiple substance use prevention category, long term effects were found in terms of lowered single and multiple drug use as well as reduced alcohol consumption for intervention participants that used an Internet program. However, the results were limited to female adolescents only.

### WEB-BASED SEXUAL HEALTH INTERVENTIONS

Seven studies addressed sexual health through the use of e-health interventions. All were focused on youth ranging from grade 7 and 8 youth, to youth up to 24 yrs. of age.

Three Canadian studies focused on increasing STI testing including Chlamydia and Gonorrhoea (Mann, Uddin, Hendriks, Bouchard, & Etches, 2013), and general STI testing, counselling and education using technology (Shoveller, Knight, Davis, Gilbert, & Ogilvie, 2012). The first study, launched a **get tested campaign** in Ottawa in 2011, targeting 15- 29 year olds to use a **bilingual, youth-friendly website to get information and answers to STI questions, plus a texting service** (Mann et al., 2013). Visitors were also assessed for appropriateness for testing and then downloaded relevant forms and submitted samples to a local laboratory. Similarly, the second study engaged 15- 24 year BC youth to use an **online service for STI/HIV testing plus get counselling and education via live chat email, or moderated forums with a nurse** (Shoveller et al., 2012). Ottawa participants indicated gaining more knowledge, such as information about services for testing, and risks of contracting STIs and felt that they would change behaviour such as asking partners to get tested and use condoms. Online services appealed to BC youth in terms of convenience, privacy, and quick access to testing and/or counselling, however, they appeared to have a relatively low tolerance for what they felt were antiquated technologies (printing forms).

Moreno and colleagues (2009) investigated the impact of a physician sending cautionary messages sex and substance abuse on the social networking site – MySpace. Profiles (n=1340) of 18-20 year olds who were living in high risk areas were assessed using set criteria to identify those at-risk (n= 14,2%), based on self-descriptions. The intervention consisted of a **physician sending information via email (e.g., information on resources, STIs, and testing), to profiles in MySpace logged in under a Dr. Meg profile**. After 3 months, profile assessments showed a 13.7% drop of sexual references in the intervention compared to 5.3% in the control group and proportion of protective measures noted was 42.1% versus 29.5% respectively.

The youngest group to be studied involved urban, low income, grade 7 and 8 students in an STI, HIV and pregnancy prevention program in Texas– **It’s Your Game: Keep it Real** (Tortolero et al., 2010). The intervention in this RCT mixed a **classroom lesson with online journaling and individual activities in a virtual world interface targeted at risk taking behaviours and student feedback**. Activities were tailored to gender and sexual experiences. Follow ups showed more oral, vaginal and anal sex by the 9<sup>th</sup> grade among controls (comparative schools) versus the intervention school youth.

Three US papers addressed risk behaviours through a variety of mixed web-based or mixed media technology interventions for youth. One study was geared for teens being treated for substance abuse (Marsch et al., 2011), a second was for HIV positive youth (Markham, Shegog, Leonard, Bui, & Paul, 2009), and the third was aimed at youth in the general public (18-24 yrs.) recruited through Internet for intervention sample (Bull, Pratte, Whitesell, Rietmeijer, & McFarlane, 2009). Interventions were quite distinct. The intervention for youth with substance use disorders was an **educator-driven STI, HIV, Hepatitis prevention program with 25 web-based modules** (Marsch et al., 2011). HIV positive youth were provided with **CLICK- this tailored application including individualized activities, animations, peer and expert video**, all of which was built based on the intervention “It’s Your Game: Keep it Real” described above in the study above (Tortolero et al., 2010). The final study was aimed at general youth and delivered a **single session theoretically driven interactive program delivered via the web or a clinic kiosk** (Markham et al., 2009). Following completion of a baseline risk assessment, each individual was exposed to a **60-90 second “role model story”** using pictures and audio matched to youths’ demographics focusing primarily on condom use. All but the last study showed positive results for the intervention, such as increased knowledge (e.g., HIV prevention and condom use), improved attitudes and beliefs (e.g., increased intentions to use condoms, positive attitudes about safe sex and condom use), and increased self efficacy related to abstinence or delayed sex (Marsch et al., 2011; Markham et al., 2009). The pre-post study involving a single short session on condom use had very small effect and resulted in a negative effect of the short story on the perceived ability to use a condom with a partner. All studies had small to modest sample sizes.

Summary: Studies addressing sexual health were aimed at youth from grade 7 and 8 to 24 yrs. of age. Web-based interventions varied widely in this group of studies. They included youth-friendly bilingual websites; online STI services; counselling and education via live chats, email or nurse moderated forums; emails from a physician (Dr. Meg) related to testing, resources and STIs in MySpace; classroom lessons; online journaling; activities in a virtual world; educator driven prevention through 26 web-based modules; animations; peer and expert videos; and single session interactive program with a 60-90 second role model story. Outcomes included increased knowledge about STI testing, services, and risks of contracting STIs, increased intention to get tested and use condoms, increased self-efficacy related to abstinence or delayed sex, drop in sexual references in MySpace, increase in protective measures in discussions, lower oral, vaginal and anal sex by grade 9 compared to controls. Only one negative outcome was seen in reduced perceived ability to use a condom following the 60 -90 second video short stories. Overall, there was greater variety and effective web-based interventions used to address sexual health promotion than for other health issues.

## WEB-BASED INFECTIOUS DISEASE PREVENTION INTERVENTIONS

A UK study conducted during the 2010 influenza pandemic explored the impact of a web intervention aimed at increasing hand washing in the home also based on the TPB (Yardley, Miller,

Schlotz, & Little, 2011). The intervention group (randomly assigned) was exposed to **4 sessions of tailored motivational messages and self-regulation support** (n= 324) which was compared to a control (no intervention) (N=172). Hand washing rates were significantly higher in the intervention group at 4 weeks ( $p < .001$ ) and 12 weeks ( $p < .001$ ) compared to controls. There were no differences by gender, socioeconomic level or level of perceived risk.

Summary: Tailored motivational messages and self-regulation support can increase hand washing in the home.

## WEB-BASED INJURY PREVENTION INTERVENTIONS

Social Cognitive theory was applied in designing a website for hip fracture prevention among the elderly and examined in two papers (Nahm, Resnick, Degrezia, & Brotemarkle, 2009; Nahm et al., 2010). A mixed RCT and qualitative study involved 245 mostly female (78.4%), white (91%) adults with an average age of 69.3 (SD=7.7). Most had some college education or higher. The interventions consisted of **learning modules on osteoporosis, falls and fractures, diet, and exercise, with and without a moderated discussion**. Additional links were added to the no discussion group intervention. Over the brief 2 week intervention, the discussion board was popular. Ninety participants actively shared their health problems, concerns, and strategies to motivate themselves and supported each other. The intervention group with the moderated discussion was more satisfied but their self-efficacy was lower. Both groups showed improvements in most outcomes (knowledge) although self-efficacy and exercise behaviour showed no significant changes.

A quasi experimental study was conducted in Spain to explore knowledge and behaviours related to sun exposure of Spanish adolescents (N= 529; aged 12-16 yrs.), using an Internet-based system and to test if such a system could improve knowledge and behaviour (Buendia Eisman et al., 2013). The intervention (**lessons on sun safety, games and links**) group showed significant reductions in self-reported sunburns in comparison with controls (no intervention) after adjusting for sex, and inland/coastal location (OR = 0.45, 95% CI = 0.23–0.87, P = 0.018). There was also a significant improvement in physical protection, frequency of sun screen use (every 2 h), and use of protection on cloudy days.

Summary: A short web-based hip fracture prevention web intervention for older adults showed some effectiveness in knowledge and behaviour. Older adults were also interested in participating in moderated discussion boards about their health. A sun safety web intervention for 12-16 yrs. olds - showed that online lessons, games and access to links led to improved protective behaviours.

## WEB-BASED INTERVENTIONS FOR RISK REDUCTION

Eight papers focused their web-based interventions on reducing risk of disease including cancer, cardiovascular disease (CVD) and diabetes.

### CANCER RISK

Three studies were aimed at increasing screening behaviour for breast (Bowen et al., 2011) and colorectal cancer (Vernon et al., 2011; Hwang et al., 2012). Web-based interventions included: access to **specialized tailored and personalized risk information and additional support such**

as “ask an expert” for breast health, and; a **tailored, interactive, computer-delivered intervention to increase colorectal cancer screening**. Although the sample in the breast screening study was not representative of the general population (those with Internet) and used self-report, the intervention group significantly increased their breast self exam (up 22%) and mammography screening (13%) rates compared to a delayed intervention control group at 1 year follow up. In the colorectal cancer study, no significant differences were seen with the tailored intervention compared to the control or the information website only group. A large online weight-loss community was surveyed to assess the acceptability of **sharing and receiving online narratives about colorectal cancer screening** (Hwang et al., 2012). Of those who reported being up-to-date with screening, 39% were interested in promoting screening by sharing narratives online and of those not up-to-date, 63% were interested in receiving narratives from others: The vast majority (93%) preferred text versus audio or video messages.

A Mexican and Spanish study addressed adolescent lifestyles to reduce cancer risk, including smoking, dietary and alcohol intake, sedentary lifestyle, obesity and sun exposure (Lana, Faya-Ornia, & M.L., 2013). Based on a **transtheoretical model, a web-based intervention with and without supplemented text messages** was compared with controls at 9 months. F&G intake was improved in all groups. Cancer behavioural risk scores were significantly reduced in both experimental conditions with the text supplemented group improving over time (OR=1.62). Study limitations included voluntary participation and self-report of behaviour change.

**Summary:** Mixed results were seen from web-based, personalized cancer risk information plus an “ask an expert” intervention for breast health, and; a tailored, interactive, computer-delivered intervention to increase colorectal cancer screening. Breast self exam and mammography screening rates increased by 13% and 22% respectively for the intervention, but no differences were seen in colorectal screening rates between the intervention and controls. However, in an online weight loss community, members were open to telling and hearing stories about colorectal cancer screening delivered by text, but not audio or video. A Mexican/ Spanish study tested a web-based intervention that addressed multiple lifestyle factors with and without supplemented texts aimed at youth to reduce cancer risk (e.g., sun safety, diet) with positive results (e.g., increased F&G intake), particularly with added text messages.

## REDUCING RISK BEHAVIOURS FOR CARDIOVASCULAR DISEASE AND DIABETES

Zbib, Hodgson, and Calderwood (2011) analyzed the demographic characteristics of users of a Canadian web resource aimed at assessing and providing tailored feedback for CVD disease risk. Use of a freely available online Health Risk Assessment (HRA) tool hosted by the Heart and Stroke Foundation was analyzed (February 1 to July 25, 2010). Results indicated that 56,437 HRAs were completed over the six months (43,717 were Canadians between 18 to 79 yrs. of age). Women made up 73.9% of users compared with Canada’s population, and were more likely to be: a) married or in a common-law relationship, b) of higher socioeconomic status (determined by education and employment), and c) reported risk factors such as overweight/obesity, hypertension, or stroke. Given that the audience was not representative of the Canadian population, the authors suggest that organizations that create and host eHealth tools for promotion and prevention should diversify their marketing approaches to reach broader audiences.

Three studies evaluated the impact of web-based interventions aimed to reduce risk behaviours related to cardiovascular disease (CVD) and diabetes including adults and teens. Wijdenes et al. (2013) explored whether providing **diabetic familial risk information using web-based tools in**



**addition to tailored diabetes prevention information** (to reduce saturated fat intake and improve physical activity) led to improved self-reported risk-reducing behaviour by healthy adults. For those at familial risk, there was no effect on risk reducing behaviours other than self-reported saturated fat intake among low-educated participants ( $\beta = -1.01$ , 95% CI,  $-2.01$  to  $0.00$ ). For those without a family history, there was no effect on risk-reducing behaviour or perceived risk. Bosak and colleagues (2010) compared an evidenced-based PA internet intervention which included **education, goal setting, and standardized feedback to reduce CVD risk** among adults diagnosed with metabolic syndrome compared with a control (MD advice and consult with a dietitian). No significant differences were seen between groups. Colkesen et al., (2011) conducted a prospective study to investigate the effect of a **web-based health risk assessment with tailored feedback** on CVD risk of among 368 voluntary employees at a Dutch worksite. Participation reduced CVD disease risk by almost 18% of those at high CVD risk and by close to 5% among all participants.

A study from New Zealand applied the **common-sense model (CSM) of self-regulation in developing brief, computerized programs aimed to increase knowledge of CVD risk and motivate protective actions** among sedentary young adults (18-35 yrs. of age)(Lee, Cameron, Wunsche, & Stevens, 2011). CSM-based imagery and textual information delivered tailored messages about the effect of diet and exercise over time on the heart. Using images is thought to motivate behaviour change. **Four personalized programs were designed –a combination of disease risk imagery and text to motivate behaviour, imagery alone, text alone, or a control** (no disease risk imagery or text). Overall, results showed that such health communication programs which included imagery and text that were tailored to individual risk factors resulted in short term changes in understanding of CVD risk and increased healthy behaviours (PA and healthy eating). The 3D animated images impacted more than text information on most measures including motivation to take protective actions. However both were effective in the short term.

**Summary:** The Heart and Stroke’s online Health Risk Assessment tool was used by over 50,000 users over 6 months but users tended to be married or common females, with higher income and currently suffering from disease indicating the need to targeting other population groups. Three studies designed to test the effectiveness of Internet risk assessment for CVD or diabetes to change health behaviours. They involved adults and teens, adults diagnosed with metabolic syndrome, and Dutch workers. Interventions ranged from education, goal setting, and/or tailored feedback, as well as a diabetes familial risk assessment which had mixed results. The diabetes risk assessment intervention was effective in reducing fat intake for those at risk and the workplace intervention was successful in reducing CVD risk by almost 18% of high risk and close to 5% of all participants. The use of images and text impacted various but different aspects of risk perception and behaviour change related to diet and exercise indicating the need to include both in preparing messaging.

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## M-HEALTH BASED INTERVENTIONS

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A review of the literature related to the use of mobile technology for health conducted between August 2006 to August 2011 (Bastawrous & Armstrong, 2013) found that Smartphone use in high income countries was found to be growing. Although there are numerous mobile phone applications for healthcare workers and consumers, the majority lack evidence about their effectiveness. The following section reports on papers retrieved related to mobile technologies.

## MOBILE HEALTH INTERVENTIONS AND EFFECTIVENESS

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Studies involving mobile health (mHealth) technologies as part of the intervention (n=5) or as the main part of the intervention (n=13 studies) were found in the literature search. Of these 18 studies, 14 of them focus specifically on text messaging, 2 focused on mobile applications, 1 focused on a mobile decision support device, and one was a more general study looking at motivators and barriers to the use of a mobile phone healthy lifestyle program.

A variety of public health issues were the focus among the 18 study interventions including smoking cessation, increasing physical activity, promoting healthy sexuality, increasing vaccination uptake, and general and/or multiple healthy lifestyle behaviours. The following sections will describe the interventions and their effectiveness by the main health issue examined.

### MHEALTH SMOKING CESSATION INTERVENTIONS

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The literature on smoking cessation interventions reveals promising, yet mixed results regarding the effectiveness of the interventions in changing smoking behaviours. The results are promising in that it appears that individuals are accepting and responsive to text messaging interventions. For example, a US study by Abrams et al. (2012) examined the acceptability of a **personalized, interactive mobile health** intervention to promote smoking cessation. Studied among an undergraduate population, the **'text2quit'** program sent text messages and emails timed around quit dates over a three month period. Message content was based on social cognitive theory constructs. The results indicated that the majority of participants enjoyed the program at 2 and 4 weeks post-enrollment (90.5% and 82.3%, respectively). Texts were read by 75% of participants. In addition, they made an average of 11.8 responses to texts over a 4 week period; however response rates declined after the quit date.

Likewise, Naughton and colleagues (Naughton et al., 2012) conducted a RCT to evaluate the feasibility and acceptability of a **tailored pamphlet in conjunction with text messaging** as a self-help intervention among a sample of pregnant smokers. In the trial, called **'MiQuit'** participants were randomized to the intervention group receiving a tailored self-help pamphlet followed by an 11-week program of tailored text messages, or to the control group receiving a non-tailored pamphlet. The trial was guided by three behaviour change theories: social cognitive theory, the perspectives on change model, and the elaboration likelihood model. In terms of feasibility, 94% of MiQuit respondents reported receiving both intervention components. In terms of acceptability, only 9% of MiQuit users chose to suspend the text messages. Compared with the control group, MiQuit participants were more likely to set a quit date ( $p = .049$ ) and reported higher levels of self-efficacy ( $p = .024$ ), harm beliefs ( $p = .052$ ), and determination to quit ( $p = .019$ ).

Lastly, Devries, Kenward and Free (2013) describes the timing and predictors of crave and lapse text messages that participants sent during a **text messaging cessation trial**. Sixty eight percent of participants who sent any text messages, sent 'crave' messages when the urge to smoke came while 70% of participants texted 'lapse' when they had a cigarette. Half of all 'crave' texts were sent within 106 hrs of quitting. Of those who lapsed, being a young aged female and setting a Saturday quit date were predictors of sending a 'lapse' text. Thus, there is evidence that smoking cessation interventions are feasible and participants are accepting of them; however results may not necessarily be generalizable to all smokers wanting to quit.

When examining the *efficacy* of smoking cessation mHealth interventions, results are not consistent. Free and colleagues (Free et al., 2009; Free et al., 2011) conducted a text messaging

intervention in the UK. The **'txt2stop' trial is an automated smoking cessation program**. After setting a quit date, participants received 5 motivational text messages daily for the first 5 weeks and then 3 a week for the next 26 weeks. Messages also provided behavioural change support and positive feedback. In the pilot study (Free et al., 2009), short term results at 4 weeks showed a doubling of self reported quitting from 12% in the control group to 26% in the intervention group. However, there were no statistically significant outcomes to report on at 6 month follow up. Two yrs. later the main study (Free et al., 2011) examined a primary outcome of continuous smoking abstinence, which was biochemically confirmed at 6 months follow up. Abstinence was increased in the txt2stop group (10.7%) versus the control group (4.9%) ( $p < 0.0001$ ). Thus, these two studies indicate different outcomes given the differing measures used to confirm cessation (self-report versus biochemical).

The third smoking cessation intervention examining efficacy took place in New Zealand. This RCT assessed effectiveness of a **multimedia mobile phone intervention**, based on social cognitive theory (Whittaker et al., 2011). The **'STUB IT'** intervention used observational learning through **short video diary text messages from role models** going through the process of quitting. Among the 226 randomized participants, continuous self-reported abstinence at 6 months was 26.4% in the intervention group and 27.6% among controls, however these results were not statistically significant ( $P = 0.8$ ). Positive feedback regarding usability of the intervention was reported. This study had difficulties recruiting young smokers and reaching target recruitment numbers.

**Summary:** Individuals are accepting and open to text messaging interventions to encourage smoking cessation. However, results are varied in terms of effectiveness. While short term self-reported smoking cessation outcomes were indicated using motivational text messages, long term results were not significant. However, when cessation was biochemically confirmed over the same follow up period in a later trial, abstinence significantly increased in the intervention group. Using text messages to promote cessation did not result in significant abstinence outcomes.

## MHEALTH PHYSICAL ACTIVITY INTERVENTIONS

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Three of the five physical activity studies were RCTs, grounded in behavioural change theory and used text messaging to deliver the intervention. However, target audiences varied including adolescents, moms, and the general adult population.

First, Sirriyeh, Lawton and Ward (2010) used **affective and instrumental messages based on the TPB** as a strategy to increase PA levels in adolescents. Participants ( $n = 120$ ) were randomly assigned to 3 experimental groups (instrumental messages, affective messages and combined) or a control group (generic messages) and received **text messages for 2 weeks**. The results indicated that for inactive participants, receiving messages about affective gains (e.g. pleasurable, fun) from PA were more effective at increasing PA levels than receiving messages about the instrumental gains (e.g. health benefits) from PA.

Next, Fjeldsoe and colleagues (2010) focused their acceptability and feasibility text messaging trial on postnatal moms in order to increase their physical activity levels. Grounded in the constructs of social cognitive theory, 88 women were randomized to an intervention or minimal contact control group. In addition to **tailored text messages**, participants in the intervention **also received face-to-face goal-setting consultation** and a support person. Women in the intervention group significantly increased their physical activity frequency by 1.82 days/week ( $p = .038$ ) and walking for exercise frequency by 1.08 days/week ( $p = .02$ ) by the 13 week mark.

Prestwich, Perugini & Hurling (2010) looked at the effectiveness of two **text message interventions, based on implementation intention theory**, in promoting brisk walking in a sample from the UK. Participants (n=149) were randomized to one of three conditions (implementation intention and text plan reminder, implementation intention and text goal reminder, or control). Both intervention groups increased their brisk walking levels compared to the control group, without reducing other physical activity. The group that received a reminder about their walking goals lost the most weight among the three groups.

The remaining physical activity studies focused on **mobile phone applications**. First, King et al. (2013) targeted a sample of aging adults to participate in the feasibility testing of three applications, based on behavioural science theory, to promote daily PA and reduce sedentary behaviours. Three types of applications were used: analytic, social and affective. The three applications significantly improved regular moderate-to-vigorous physical activity levels and decrease sitting time during the 8-week period. Acceptability of the applications was also established. Second, a matched case-control trial conducted in Australia (Kirwan, Duncan, Vandelanotte, & Mummery, 2012) studied the effect of a **smartphone application on self-monitoring and self-reported physical activity levels** among members of a larger physical activity program (10,000 Steps Australia). The **iStepLog application** allows participants to record their daily PA levels on their mobile device and harmonize this information with their online Step Log. The use of the application was associated with an increased likelihood to log steps daily during the intervention period compared to those not using the application (odds ratio 3.56, 95% confidence interval 1.72–7.39).

Important factors to consider about mobile applications is that they are not always grounded in evidence based guidelines and theoretical constructs as reported by Abroms et al. (2011) and West et al. (West et al., 2012). After conducting a content analysis of 47 iPhone applications specifically targeted to smoking cessation, Abroms and colleagues (2011) found that the applications had low levels of adherence to fundamental cessation guidelines and lacked in connecting users to evidence based cessation techniques and other supports. Similarly, West et al. (2012) examined the content of over 3000 paid health and fitness applications, and found that less than 2% of the applications examined were grounded in a comprehensive set of behaviour change principles (predisposing, enabling and reinforcing change). Thus, health consumers need to be aware of the application content they are using to change their health behaviours.

**Summary:** The content of the text messages that is sent in a PA intervention is important. The three texting interventions show that theory grounded messages that use affective gains messaging, are tailored, in conjunction with face to face support and that focus on PA goals/plans can be effective in increasing PA levels among different audiences. Mobile phone applications to self-monitor and improve PA outcomes are effective but one needs to be cognizant of the plethora of behaviour change applications available that are not necessarily evidence based in content.

## MHEALTH SEXUAL HEALTH INTERVENTIONS

Sexual health intervention studies reported on HIV prevention among African American adolescents in the US, and sexual health promotion among young adults in Australia. The results from these studies provide relevant evidence for sexual health programs across Canada. First, Cornelius et al. (2013) reported on young adults aged 13-18 who received **daily multimedia text messages** aimed to change beliefs and sexual behaviors. Results revealed that older adolescents (16–18 yrs. old) had greater HIV knowledge, improved attitudes toward condoms, and increased

perceived HIV risk scores. Behaviour trends also showed a decrease in the number of times participants reported engaging in unprotected sexual intercourse over the previous 2 months.

A qualitative study by Gold and colleagues (2010) explored the impact of young participants receiving 12 **sexual health related text messages as a sexual health promotion** method. Twenty one males and 22 females participated. Results revealed that this was an effective method to engage youth. Messages were perceived as an acceptable and 'personal' method of health promotion. Messages that were positive, applicable, short and explored a range of topics were preferred.

**Summary:** Young adults are accepting of receiving text messages to promote healthy sexuality as long as the messages are brief, relevant and positive. Daily multimedia text messages have been shown to change sexual health beliefs and behaviours in a positive way among older teenagers. Overall, this method of engagement among this impressionable population is feasible.

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### MHEALTH IMMUNIZATION UPTAKE INTERVENTIONS

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There are two mHealth studies that examine the uptake of immunizations via a **text messaging intervention called 'Text4Health'** both taking place in New York City. First, Kharbanda et al. (2009) used a qualitative approach to explore preferences and readiness for text message **immunization reminders** sent to parents with adolescent children. Content analysis of the transcripts revealed that text message reminders were well-accepted by parents (n=28) and many thought they would be more effective than standard reminder methods. Parents also preferred the text message reminders to be concise and tailored.

The second study by Stockwell and colleagues (2012) took a quantitative approach by conducting two independent, randomized studies with two different goals. First, they aimed to assess the impact of sending a series of **text message reminders to parents** to obtain adolescent patient's receipt of **1 or 2 routinely recommended adolescent vaccines**. Second, they aimed to evaluate the impact of using **text messages** to mobilize parents of young children under 2 yrs. of age that were under immunized **to attend special immunization sessions**. Statistically significant results indicated that there was a difference of 11% at 4 weeks, 13% at 12 weeks, and 18% at 24 weeks in favour of the text intervention group where their children received either or both of the recommended vaccines. Similarly, for the study with the younger sample, 21.8% of parents who received a text message attended a special immunization session to get their child's vaccines up to date compared with 9.2% of those who received just a letter (p=.021).

**Summary:** Utilizing text messages to remind parents of their child's immunization schedule is accepted and preferred as long as the content is tailored and succinct. In addition, sending text messages to parents has shown to prompt parents to take their children to get immunized more so than receiving a traditional reminder letter.

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### MHEALTH HEALTHY LIFESTYLE/DIET INTERVENTIONS

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The remaining mHealth interventions examined adherence to vitamin C intake, changes to diet and PA, and motivators and barriers to continued engagement in healthy lifestyle programs.

First, a Canadian RCT by Cocosila, Archer, Haynes and Yuan (2009) recruited participants from a university to determine the effectiveness of text messaging for improving adherence to a healthy behaviour (taking vitamin C). Participants received **text message reminders** while the control

group received no intervention. The messages, sent by an automated system from a **virtual friend**, were informal and funny with captivating content and language. Both groups reported an increased adherence after the trial: by 246% for the intervention group and by 131% for the control group. However, when adherence to pill consumption was analyzed at the end of the trial, no significant differences were reported between the two groups in terms of the number of missed pills.

An American RCT (Spring et al., 2012) sought to determine which combination of advice to change dietary behaviour (high saturated fat or low F&G intake) and activity behaviour (high sedentary leisure or low PA) would maximize healthy diet and PA change during treatment and follow-up. Two hundred and four adults recruited from community ads were randomized to one of four treatments: They were a combination of interventions to increase F&G intake, increase PA, decrease fat and/or decrease sedentary leisure. Treatments provided **3 weeks of remote coaching supported by mobile decision support technology to self-monitor with added financial incentives**. Positive outcomes for F&G consumption and sedentary leisure were greater than the other treatments ( $p < .001$ ) and differences were sustained through follow up. Specifically, daily F&G intake increased by 4.2 servings, sedentary leisure decreased by 129.9 minutes, and saturated fat decreased by 2.5% of calories consumed. This study involved mainly a female sample (75%).

The last mHealth study explored the applicability of potential components of a **mobile phone-based healthy lifestyle program** and to understand motivators and barriers to continued engagement in such a program (Fukuoka, Kamitani, Bonnet, & Lindgren, 2011). Six focus groups were conducted with 35 participants (mean age 51). Open ended questions explored knowledge, beliefs, and attitudes about diabetes, PA, diet, and weight control. Valuable information was gained such as the type of support that individuals prefer (real-time social support from peers going through the same process and professional support), the type of programs they would prefer (tailored), what they wanted to get out of programs (self-monitoring and motivation) and potential barriers to sustaining such a program (fear of failing, age factor, loss of interest over time).

**Summary:** mHealth interventions looking at healthy lifestyle/diet interventions varied in their approach and outcomes. One study examined text messaging versus no text messaging to increase vitamin intake: While results were in favour of the intervention group, no significant differences were found. A mobile decision support intervention used a remote coach to change diet and PA with significant positive results for F&V consumption and reduced sedentary leisure. A qualitative study showed tailored programs and real time support were preferred, but age and loss of interest are challenges that must be overcome in mHealth interventions looking to change behaviours.

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## COMPUTER-BASED INTERVENTIONS

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Two studies were found which reported on computer-based interventions. A study by Mauriello et al. (2010) engaged 1800 high school students from four US states in '**Health In Motion**' - a **multi-media intervention**, based on the **Transtheoretical Model of Behaviour Change**, to prevent obesity. The intervention addressed PA, F&G consumption, limited TV viewing, compared to a no-treatment group. The intervention consisted of a **30 minute program with a series of theory based assessments with tailored feedback messages in the school computer lab with interventions occurring at 1 and 2 months** and outcomes followed to a year. The intervention group showed significant positive changes in PA and F&G intake compared to controls. But, no differences were found between groups for limiting TV viewing. However, the intervention group reported more days being active for at least 60 minutes at 2 months (3.38 versus 2.72) compared to

the control group. The intervention was most effective in significantly increasing F&G intake compared to controls at 2 months (3.86 versus 3.0), 6 months (3.55 versus 2.73), and 12 months (3.67 versus 2.97). Overall, the intervention helped motivate students initiate healthier behaviours as well as helped to maintain those already participating in healthy behaviours. Positive behaviour changes (students progressing to 'action' or 'maintenance' phase) were seen in the intervention group. Outcomes were based on self-report.

In light of the Olympic success of our Canadian hockey teams during the preparation of this review, it is appropriate that the last paper, a Canadian prospective cohort study, explored a concussion education intervention for junior ice hockey players (Echlin et al., 2010). The intervention was delivered by DVD or an interactive computer module compared to an unmatched control. Knowledge related to concussions was measured following 15 games (50 days) and 30 games (91 days) and at baseline. Results for both eHealth interventions were positive at both follow up periods compared to controls, although they were not statistically significant.

**Summary:** A 2 month, 30 minute computer intervention based on the Transtheoretical Change Theory involved assessments with tailored feedback aimed at high school students to prevent obesity. The intervention was particularly effective in increasing F&G intake, which was sustained over time. It also helped motivate students to initiate and maintain other healthy behaviours (e.g., PA). TV viewing was not impacted. Self report was the main limitation. A DVD and interactive computer module showed effectiveness, although not statistically significant in increasing junior ice hockey players knowledge about concussions compared to controls.

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## DISCUSSION AND RECOMMENDATIONS

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A brief discussion with recommendations will be integrated in this next section. Studies were categorized into three main groups. First, eHealth interventions reported in 77 papers investigated unique web-based interventions. The next largest category of interventions included 18 studies that applied mHealth interventions. Only two papers addressed the computer-based intervention category. This is not surprising given the rapid increase in Internet access and growing ownership of Smartphones or hand-held computers and the years spanned in this review.

Although there were fewer Canadian studies than those conducted in the US or Western Europe, they contributed new knowledge in each of the three categories: web-based interventions (Plotnikoff et al., 2010; M. Kwan et al., 2013; Cavallo et al., 2012; Danaher et al., 2013; Cunningham, 2012; Mann et al., 2013; Shoveller et al., 2012), one mHealth intervention (Cocosila, Archer, Haynes, & Yuan, 2009) and one computer-based intervention (Echlin et al., 2010). Three collaborative studies were conducted in the US and Canada: Two tested web-based interventions for a gender-specific drug abuse prevention program for teen girls (Schwinn et al., 2010) and a chewing tobacco cessation program (Danaher et al., 2013), and the last explored preferred sources of health information by Chinese immigrants (Woodall et al., 2009) **Given this paucity of Canadian studies, more research is needed to explore eHealth interventions in a Canadian context.**

There were three key population groups engaged in the eHealth intervention studies in this review. Papers most often focused on the general public, followed by students, and employees in workplaces. Youth, and students, but rarely elementary students, as well as adults were targeted most often. A large number of studies targeted youth in relation to improving healthy eating and PA. In addition, young adults were also most often involved in studies related to sexual health, such

as increasing STI screening, as well as adopting healthier sexual health behaviours. Employee interventions targeted multiple lifestyles mostly related to healthy eating and increasing PA. **EHealth interventions should be considered as a complement to workplace health and school programs in relation to PA, healthy eating and sexual health topics as relevant.**

Only a few papers considered interventions with seniors, a significant and growing population group. For example, one paper examined seniors' use of mobile phones and the second focused on a web-intervention for older adults, both of which aimed to increase PA. In light of the aging demographic in Canada, the increased use of the Internet among those over 55 years of age in Canada, the lack of interventions with this population, and the promise shown in the above studies, this is a potential area for growth. **EHealth interventions should be further explored for effectiveness in its application for seniors.**

Numerous public health topics were addressed such as: multiple lifestyle issues, increasing PA (including reduction of sedentary activity and TV watching), healthy diet (reduction of fats and sugars, increase in F&V, Calcium, Vitamin C), healthy weights, substance use (including tobacco cessation, alcohol reduction and multiple drug use), sexual health (including sexual health promotion as well as promotion of screening/testing behaviours), risk reduction (for cancer diabetes and CVD) and injury reduction including hip fractures and sun safety. Topics studied less often were in the area of health protection: papers including immunization uptake, communicable disease (hand washing in the home) as well as protective behaviours for STI prevention. A variety of these health topics were addressed by Canadian studies: uptake of vitamin C, reduction in alcohol use and smokeless tobacco, increase in PA, increase access to sexual health risk and testing, general health seeking behaviours, drug use reduction and increasing knowledge of concussions by hockey players. Interestingly, over half of these studies targeted adolescents, and young adults. **The literature supports the use of eHealth interventions to support health promotion and prevention, however, protection was less often addressed and requires more study.**

With respect to healthy eating, applications of web-based interventions in schools and college environments showed positive outcomes such as increased F&V and calcium intake, and fat reductions, particularly where there were more active interventions. Similar to PA interventions, tailored feedback, personalized goal setting, self-monitoring interactive modules, counselling, and social networking were related to positive changes. Similar findings were reported in web-based workplace health interventions, some of which added monetary group incentives, and food diaries. Further, web interventions such as the application of video enhancements and intensive coaching or motivational interviewing by email, and the use of weight trackers supported weight loss and reduced fat consumption in the general public. These results are corroborated by Coons and colleagues, Enwald and their team, as well as Wittemore, Jeon and Grey's systematic reviews on technology applications to address obesity (Enwald & Huotari, 2010; Whittemore, Chao, Popick, & Grey, 2013; Coons et al., 2012). It should be noted that one workplace study had negative outcomes related to increased blood glucose and increased systolic blood pressure over time although participants experienced weight loss (.34 lbs) and reduced cholesterol and LDL. (McHugh & Suggs, 2012) The authors identified difficulties in promoting the program well as sample size limitations.

In terms of effectiveness, outcomes varied by intervention design and health topic. Multiple web-based or mixed interventions in school/college environments tended to result in positive outcomes particularly for increasing PA and healthy eating. Outcomes for reducing sedentary behaviour and TV watching were less successful. Active use of websites was related to better outcomes, and



enhanced sites with more interactive features were effective in increasing and maintaining PA. Similarly, Hamel, Robbins and Wilbur's (2011) review of computer and web-based PA interventions found positive outcomes to increase PA, although results were not sustained in the long-term. The use of tailored feedback, personalized goal setting, interactive learning modules, counseling, and communication through social networking were related to positive behavioural changes. Davies and colleagues conducted a meta-analysis which supports the addition of educational components to increase effectiveness of web-based interventions to increase PA (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012). Further, a systematic review by Lau and colleagues (2011) concluded that the use of information and communication technologies for PA behavior change was particularly effective when used with other delivery approaches such as face- to face interactions. A unique study which involved a web based eHealth intervention that was tailored to a neighbourhood also showed positive results in increasing PA. (Ferney et al., 2009)

**Web-based interventions that are tailored, and combined with other interventions (e.g., face to face, goal setting, self-monitoring, educational components and counselling) appear to show some effectiveness in promoting PA and healthy eating and should be considered in public health programming.**

Results for web-based alcohol consumption reduction interventions, most using tailoring strategies, indicated mostly positive and significant outcomes. Two systematic reviews of computer-facilitated and/or web based alcohol and drug prevention programs in schools (Champion, Newton, Barrett, & Teesson, 2012) and with adults in and outside of schools (Khadjesari, Murray, Hewitt, Hartley, & Godfrey, 2011) also indicated potential to reduce alcohol consumption. **Computer and web based interventions have evidence to reduce alcohol consumption and should be encouraged.**

The majority of web-based smoking cessation studies focused on tailored versus non-tailored content or type of technology used in changing smoking behaviours. Others have argued that the use of tailoring for smoking and alcohol interventions has been low (Lehto & Oinas-Kukkonen, 2011) although self-monitoring, simulation and personalization were commonly used in web-based interventions. Outcomes were mixed for effectiveness in the current review. Programs using tailored content were significantly effective in the short term, however, two of six studies found no significant outcomes. Others reviews have found positive effects of web and computer based smoking cessation programs (Myung, McDonnell, Kazinets, Seo, & Moskowitz, 2009) as well high acceptability and success of web based tailored, interactive smoking cessation interventions compared to untailored booklets or email interventions up to 6 months post interventions (Shahab & McEwen, 2009). **Tailored and interactive computer and web based interventions demonstrate good potential to support smoking cessation at least in the short term and should be further examined.**

Similarly, web studies addressing sexual health also showed largely positive outcomes and were mainly aimed at adolescents and young adults. Outcomes included increased knowledge about STI testing, services, and risks of contracting STIs, and increased intention to get tested and use condoms. A systematic review of the use of digital media (web interventions and one phone intervention) aimed at sexual health of adolescents by Guse and colleagues (2012) support these results. Further two papers led by Noar (Noar, Pierce, & Black, 2010; Noar, 2011) conclude that there is potential for HIV prevention efforts to benefit from computer-based interventions given their effectiveness in improving knowledge of HIV /AIDS, condom self-efficacy, and sexual and condom attitudes, but that further research is needed to explore how and under what

circumstances they can be most effective. **Web based interventions have shown good potential for improving sexual health attitudes, and self-efficacy related to protective behaviours and both should be encouraged.**

One common thread among all eHealth intervention papers was that studies showing the most positive and significant outcomes, regardless of health topic included mixed components (e.g. website plus face-to-face support), tailored components (personalized feedback or advice), and integrated behaviour change theory (e.g. Social Cognitive Theory). These findings were supported by Webb and colleagues' (2010) systematic review of internet interventions promoting health behaviour change concluded that enhancing internet based interventions with other strategies [communicating with users, and using texts or short messages (SMS)] improved outcomes. Another literature review reported on effectiveness of tailored web based interventions (Lustria et al., 2013). Crutzen and colleagues' systematic review focused on adolescents also supported tailored communication, reminders and incentives (Crutzen et al., 2011). These strategies are supported in the current review. **Designers of eHealth interventions need to consider enhancing web-based interventions with a mix of multiple strategies which should include tailoring.**

Studies involving mobile health technologies reported mixed outcomes. Short term self-reported smoking cessation outcomes were indicated using motivational text messages, but long term results were not significant. However, when cessation was biochemically confirmed over the same follow up period in a later trial, abstinence significantly increased in the intervention group. The lack of long-term impact was supported in a Cochrane systematic review (Vodopivec-Jamsek, de Jongh, Gurol-Urganci, Atun, & Car, 2012). Texting interventions can also be effective in increasing PA levels among different audiences. Mobile phone applications to self-monitor and improve PA outcomes are effective but one needs to be mindful of the plethora of behaviour change applications available that are not necessarily evidence based in content. O'Reilly and Spruitjt-Metz corroborated these findings adding that successful mHealth interventions tend to employ SMS (short message service) messages, mobile journaling or both (2013). They also argue for more research that includes "sequential research designs that take advantage of ongoing technology". (p.501) Williams' (2012) review of the literature concludes that text messaging used in conjunction with addition strategies is highly recommended to increase PA among healthy adults. She also offers an interesting recommendation that there should be evidence-based text message libraries available to the public on various health topics to ensure that these messages are free from commercial influence. Mobile interventions looking at healthy lifestyle/diet interventions varied in their approach and outcomes in the current review. While text messaging can increase uptake of vitamin C, no significant differences were found between groups. A mobile decision support intervention used a remote coach to change diet and PA and reported significant positive results for F&V consumption and reduced sedentary leisure. Studies in this review that involved mHealth tended to focus on the effectiveness of texting on behaviour change. Results showed that texts were most effective for PA interventions when they were grounded in theory, used affective gains messaging (positive messages that highlight benefits), were tailored, were used in conjunction with face to face support, and focused on PA goals/plans. **MHealth interventions that include text messaging have shown the most promise for increasing PA and smoking cessation and should be considered in the mix of public health interventions.**

Utilizing text messages to remind parents of their child's immunization schedule was also accepted and preferred as long as the content was tailored and succinct. **MHealth interventions that include carefully crafted text messages should be included in immunization programs.**

It is important to note that in relation to mHealth intervention studies, in all but one (King et al., 2013), participants had to own a cell phone and in some cases have a data plan. A review of mHealth interventions highlights the potential drawback of text-message based mHealth interventions that can marginalize certain populations, such as those who are illiterate or lack access to a mobile phone due to financial barriers (Cole-Lewis & Kershaw, 2010). **Is it recommended to carefully match the appropriate eHealth application to the target audience, taking into account comfort with mHealth, and particularly access to hardware (cell phones), the internet and/or data plans.**

Another common aspect was that many studies showed short term effects (<6 months), but results were lacking in the long term (>6 months). Commonly reported research limitations were: recall bias due to self-reported outcome measures rather than using objective measures (e.g. biometrics, accelerometers), limited generalizability of results due to small sample sizes and target sample demographics, high attrition rates, and loss to follow up. **Longer-term studies are recommended to explore what intervention characteristics can sustain positive outcomes.**

Largely ignored were Francophones and First Nations peoples, with the exception of one paper targeting an Inuit population in the Ottawa region (McShane et al., 2013). This review was limited to English language publications which likely resulted in a lack of papers from the Francophone population, an important limitation to take into account. **EHealth intervention work in Canada should increase their focus on Francophone and First Nations populations.**

The digital divide in Canada should be taken into account when designing eHealth interventions to ensure equitable program and service delivery of all populations. This review identified scant papers which directly addressed health equity issues indicating a need for more research and consideration for this topic. Health information through eHealth strategies needs to: be delivered in culturally and socioeconomically acceptable formats; increase skills in delivering 'accessible' health information; and engage social media superusers and trusted people (e.g., elders). To address health equity concerns, factors that need consideration include: lack of physical access to technology; lack of meaningful access (information designed to reach and appeal to diverse populations); language abilities, eHealth literacy skills (Norman & Skinner, 2006)]; age, disability and cultural relevance of tools. Kanter suggests strategies to overcome equity barriers (Kanter, 2009). Governments should: incorporate equity in e-health strategies and provide meaningful access to the Internet and improve health literacy. They need to fund programs and tools that promote health equity. **The Public Health Agency is well positioned to provide funding for public health eHealth initiatives which can overcome equity barriers.**

Given that many interventions in this review were conducted through educational settings as well as workplaces, this is a strategy that can help overcome access barriers for some populations. Public health should consider working within these settings to apply eHealth interventions to reach a broad population base. This, of course, is not a solution for the most vulnerable Canadian adults and youth who are out of school, marginally housed, and/or unemployed. Kanter (Kanter, 2009) further suggests that **partnerships are needed with public agencies and organizations (libraries, community agencies, schools) to provide access to capacity building around e-health with trusted community leaders as trainers.**

The application of theory in the design of interventions was commonly seen in most studies in this review and tended to be related to more successful outcomes. Others support this conclusion (Webb et al., 2010) and show that use of theory was associated with significant positive effect sizes, in particular through the application of the theory of planned behaviour. Further, Laplante and

Peng found consistent application of theory to eHealth interventions but with mixed results for increasing PA (2011). **Therefore, eHealth applications should continue to apply theory in the design of new eHealth interventions to support behaviour change. Social cognitive theory, the theory of planned behaviour and the transtheoretical change model are suggested as starting points.**

In addition to the use of theory, an often overlooked area is participatory design. It is critically important to engage end users in co-designing interventions to ensure relevance, uptake and sustained use of eHealth interventions (Ellis & Kurniawan, 2000; Muller, 2003). **Diverse populations need to be engaged in design of e-tools, and e-tools should be targeted to them while being culturally appropriate.**

EHealth studies testing web-based interventions for behaviour change have been conducted in primary care settings and have similarly addressed PA (Leijon et al., 2011), alcohol screening (Bendtsen et al., 2011) colorectal cancer screening (Vernon et al., 2011), weight loss (Bennett et al., 2010), and multiple health behaviours (Dickinson et al., 2013). **The overlap of research interests between primary care and public health highlights a potentially ripe area for collaboration related to eHealth interventions which should be pursued.**

There are some limitations for this review that should be noted. First the inclusion of only English language publications may have missed French language papers from Canada. Also, papers were not assessed for methodological quality due to time and resource limitations, however, limitations were taken into account as reported by authors. Self-report was the most common limitation, as well as small sample size, short follow up periods, loss to follow up, and high attrition.

In conclusion, this review provides a solid overview of eHealth interventions which have been used for health promoting and protecting behaviours and their effectiveness for public health. Recommendations should be used with caution given the lack of assessment of methodological rigor in the review. However, integration of our results and conclusions with those of others reported in multiple systematic reviews and meta-analyses strengthens the suggested recommendations provided. There is definitely room for careful application of eHealth interventions in public health work in Canada with attention needed to address challenges to health equity. There is also a dire need to support further research of eHealth applications in the Canadian context.

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