Information Technology and Lifestyle: A Systematic Evaluation of Internet and Mobile Interventions for Improving Diet, Physical Activity, Obesity, Tobacco, and Alcohol Use

ORIGINAL RESEARCH

Information Technology and Lifestyle: A Systematic Evaluation of Internet and Mobile Interventions for Improving Diet, Physical Activity, Obesity, Tobacco, and Alcohol Use

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***Background*—**Novel interventions are needed to improve lifestyle and prevent noncommunicable diseases, the leading cause of death and disability globally. This study aimed to systematically review, synthesize, and grade scientific evidence on effectiveness of novel information and communication technology to reduce noncommunicable disease risk.

***Methods and Results*—**We systematically searched PubMed for studies evaluating the effect of Internet, mobile phone, personal sensors, or stand-alone computer software on diet, physical activity, adiposity, tobacco, or alcohol use. We included all interventional and prospective observational studies conducted among generally healthy adults published between January 1990 and November 2013. American Heart Association criteria were used to evaluate and grade the strength of evidence. From 8654 abstracts, 224 relevant reports were identified. Internet and mobile interventions were most common. Internet interventions improved diet (N=20 studies) (Class IIa A), physical activity (N=33), adiposity (N=35), tobacco (N=22), and excess alcohol (N=47) (Class I A each). Mobile interventions improved physical activity (N=6) and adiposity (N=3) (Class I A each). Evidence limitations included relatively brief durations (generally <6 months, nearly always <1 year), heterogeneity in intervention content and intensity, and limited representation from middle/low-income countries.

***Conclusions*—**Internet and mobile interventions improve important lifestyle behaviors up to 1 year. This systematic review supports the need for long-term interventions to evaluate sustainability. **(*J Am Heart Assoc*. 2016;5:e003058 doi: 10.1161/JAHA.115.003058)**

Key Words: alcohol • diet • Internet • mobile • obesity • physical activity • smoking

Noncommunicable diseases (NCDs) are the leading cause of mortality and morbidity globally, accounting for 65% of deaths and 54% of disability-adjusted life-years in 2010.[1,2] Suboptimal lifestyle is the major cause of NCDs, including poor diet, physical inactivity, tobacco, adiposity, and excess alcohol.[2] Clearly, novel interventions to improve lifestyle and prevent NCDs are urgently required. In recent years, the evidence for effectiveness of conventional clinic-based education[3] and policy[4] approaches to improve lifestyle has been systematically evaluated. In comparison, the effectiveness of more novel information and communication technologies, such as Internet and mobile applications, to improve lifestyle is not well established. Such technologies are particularly promising because of potential for scalability, low cost, use in multiple settings including middle- and low-income nations, and opportunities for real-time modifications and improvements. Numerous small trials have been reported, but their findings have not been systematically reviewed.

To understand and compare the effectiveness of novel technologies for behavior change across diverse lifestyle

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Accompanying Datas S1 through S4 are available at http://jaha.ahajournals.org/content/5/9/e003058/DC1/embed/inline-supplementary-material-1.pdf

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targets, we systematically investigated, summarized, and graded the evidence for effectiveness of such interventions to improve diet, adiposity, tobacco, physical inactivity, and excess alcohol.

Methods

Search Strategy and Study Selection

Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we systematically searched PubMed for all interventional trials (randomized, quasi-experimental) and prospective observational cohorts evaluating the effect of novel information and communication technologies on diet habits, adiposity, physical inactivity, tobacco (ie, smoking cessation), and excess alcohol among adults. Eligible technologies included those based on Internet, mobile (text messages, cellphone calls, smartphone apps), personal digital assistant, and social media applications, as well personal sensors (eg, pedometers, accelerometers). The full search strategy including search terms is provided in Datas S1 through S4.

Studies were excluded if cross-sectional, ecological, or lab experiments (hypothetical situations); conducted among people with underlying prevalent disease related to the study outcome (eg, cardiovascular disease, except diabetes); only evaluating intervention feasibility or acceptability; or only evaluating changes in knowledge, awareness, or attitude. We also excluded studies with fewer than 50 subjects, or duration <1 week. Additionally, we excluded studies published prior to 1990 (because of our focus on novel technologies) or conducted only among children (because of our focus on NCDs). For diet and adiposity, our searches identified several prior systematic reviews on information and communication technologies; for these targets, we included prior identified investigations and searched for additional original articles published after the time period of search of these reports (after January 2011). Titles and abstracts of all identified articles were screened by 1 investigator; and full texts were reviewed by 1 investigator after 10% of the articles were reviewed independently and in duplicate by 2 investigators until 100% concordance was achieved.

Data Extraction

Using a standardized electronic format, data were extracted by 1 investigator on first author name, publication year, study location, design, population characteristics (sample size, age, race, sex, education), intervention characteristics (description, components, duration), study outcomes (description, assessment method), and intervention effectiveness (effect measure, uncertainty estimates). To ensure accuracy and quality of data extraction, data from 10% of studies were extracted by 2 investigators in independently and in duplicate.

Assessment of Effectiveness

In some studies, the technology intervention was compared to usual care or minimal intervention (eg, printed leaflets); and in other studies, to intensive, non-technology-based, behavioral interventions (eg, standard-of care clinical counseling). Thus, the various "control groups" received mixed interventions with varying degrees of intensity. For studies including a usual care or minimal intervention control group, intervention effectiveness was evaluated by comparing the change in lifestyle target between the 2 groups. These studies provide direct evidence for effectiveness of the intervention, compared to usual care.

For studies having a control group receiving more intensive behavioral interventions (and for quasi-experimental studies with no control), we evaluated intervention effectiveness based on change in the target lifestyle from pre- to postintervention within the intervention group. This provides better comparability of findings to studies with minimal intervention controls. However, because such results could be

Table 1. Definition of Classes and Levels of Evidence Used in This Report*

Class	
Class I	There is evidence for and/or general agreement that the intervention is beneficial, useful, and effective. The intervention should be performed.
Class II	There is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of the intervention.
Class IIa	Weight of evidence/opinion is in favor of usefulness/efficacy. It is reasonable to perform the intervention.
Class IIb	Usefulness/efficacy is less well established by evidence/opinion. The intervention may be considered.
Class III	There is evidence and/or general agreement that the intervention is not useful/effective and in some cases may be harmful.
Level	
Level of evidence A	Data derived from multiple randomized clinical trials.
Level of evidence B	Data derived from a single randomized trial or nonrandomized studies.
Level of evidence C	Only consensus opinion of experts, case studies, or standard of care.

*The American Heart Association criteria for evidence grading were used to determine the Class and Level of the evidence.

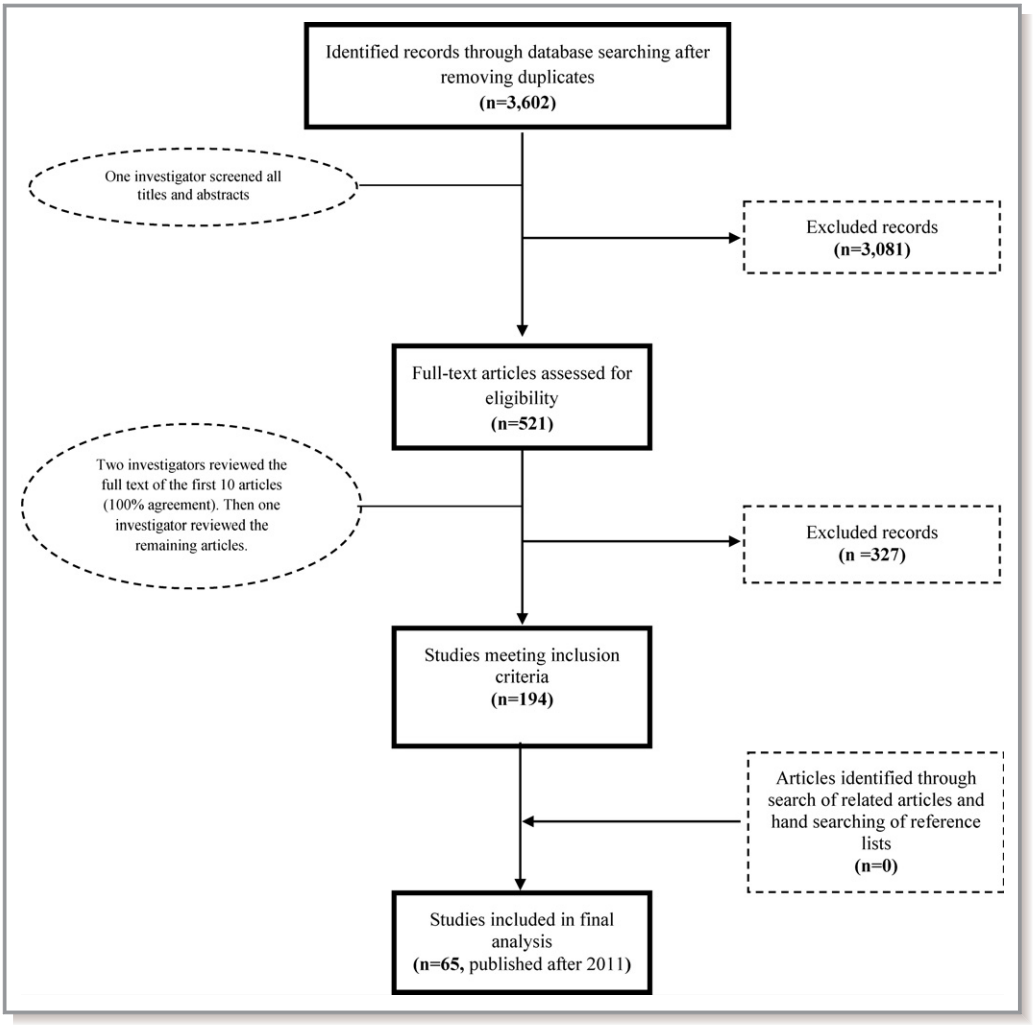

Figure 1. Screening and selection process of studies evaluating the effectiveness of information and communication technology interventions to improve diet and adiposity.

confounded by participation (Hawthorne effect), we also reviewed and summarized the findings from the comparison groups whenever relevant.

We generally separately evaluated each lifestyle target. Because many studies jointly evaluated diet and adiposity, these 2 lifestyle targets were considered and reviewed together.

Evidence Grading

Two investigators reviewed and graded the evidence independently and in duplicate, based on the American Heart Association criteria for evidence grading (Table 1).[5] Briefly, Class of recommendation (I, IIa, IIb, III) was determined based on the consistency of evidence for benefits and effectiveness of the intervention; and Level of evidence (A, B, C) was determined based on the number and types of studies (eg, clinical trials, nonrandomized studies) used to assess the intervention.

This study did not meet the definition of human subjects research because no identifiable private information was obtained for this research.

Results

Diet and Adiposity

Of 3602 abstracts screened, 65 original articles met inclusion criteria (Figure 1). These included 47 randomized controlled trials (RCTs) and 18 quasi-experimental studies. Thirty-seven studies were conducted in the United States; 26 in other high-income countries (Australia, United Kingdom, New Zealand, Belgium, The Netherlands, Austria, Korea, Japan, Germany); and 2 in middle-income countries (Iran, Brazil).[6] Settings included community, worksite, university/college, hospital/clinic, church, health club, and online populations. Study durations ranged from 1 week (examining effects of an Internet intervention on fruit intake[7]) to 37 months

Table 2. Effectiveness of Novel Information and Communication Technologies for Improving Diet and Adiposity*†‡§

Study Characteristics	Internet‖	Mobile¶	Combined Intervention#
Diet**			
All studies			
No. of studies	20	2	5
No. of effective studies (%)	14 (70%)	2 (100%)	3 (60%)
US studies			
No. of studies	12	2	2
No. of effective studies (%)	9 (75%)	2 (100%)	2 (100%)
Design			
Randomized trials	15	2	5
Quasi-experimental studies	5	0	0
Duration			
<6 weeks	4	1	1
6 weeks to 6 months	9	1	3
>6 months	7	0	1
Recommendation††			
Class of evidence	Class IIa	Class I	Class IIa
Grade of evidence	A	B	A
Adiposity‡‡			
All studies			
No. of studies	35	3	16
No. of effective studies (%)	24 (69%)	2 (67%)	13 (81%)
US studies			
No. of studies	20	2	9
No. of effective studies (%)	13 (65%)	1 (50%)	8 (89%)
Design			
Randomized trials	22	2	14
Quasi-experimental studies	13	1	2
Duration			
<6 weeks	1	0	0
6 weeks to 6 months	21	3	11
>6 months	13	0	5
Recommendation††			
Class of evidence	I	I	I
Level of evidence	A	A	A

*Studies published after 2011.
†Most studies included both men and women, with greater numbers of women than men in the majority (80%) of studies.
‡Mean age of participants was between 30 and 60 years in more than 75% of the studies.
§Numbers of participants ranged from 50 to 9600, with 19 studies having 50 to 99, 30 having 100 to 499, 8 having 500 to 999, and 8 having 1000+ participants.
‖Internet interventions mostly used a website to provide general information on healthy eating and weight management; individually tailored messages on healthy eating and weight management; individually tailored dietary and exercising plans; goal-setting and self-monitoring; and social support from professionals or other group members. Email reminders were used in some studies to reinforce the intervention.
¶Mobile interventions included text messages, cellphone calls, or smartphone apps.
#Interventions using Internet and mobile phones.
**Dietary outcomes included change in intake of fruits, vegetables, whole grains, dairy products, dietary fiber, total fat, saturated fat, polyunsaturated fat, and total energy.
††The Class and Grade was determined using the American Heart Association criteria for evidence grading[5] and after assessment of the findings of all identified studies (published before and after 2011).
‡‡Adiposity outcomes included change in body mass index, weight, waist circumference, hip circumference, waist–hip ratio, skinfold thickness, and body fat.

(examining effects of an Internet intervention on weight loss).[8] Most studies had durations between 6 weeks and 6 months; only 10 studies had durations >1 year. Details on the intervention strategies and dietary and adiposity outcomes are provided in Table 2.

We also identified 5 prior systematic reviews evaluating relevant studies published prior to January 2011, each including from 7 to 36 studies.[9–13] Table 3 summarizes the characteristics and findings of these reviews.

Of 35 studies (22 RCTs, 13 quasi-experimental) assessing Internet interventions and adiposity, 24 (69%) reported significant improvements following the intervention (Table 2). Findings were similar, limited only to RCTs, with reduced adiposity in 13 of 22 (59%) trials. In studies reporting significant weight reduction, the magnitude of weight change ranged from 1 to 6 kg after 6 months of follow-up. Of 9 studies comparing Internet interventions with higher intensity conventional interventions (rather than usual care/minimal intervention), 4 reported significantly higher weight reduction in the Internet intervention group, 4 showed both interventions were equally effective in reducing adiposity, and 1 showed no significant effect in either of the intervention groups. In a meta-analysis of 23 RCTs evaluating the effect of the Internet component of weight loss programs, using the Internet resulted in 0.68 kg (95% CI: 0.08, 1.29 kg) additional weight reduction over a period of 3 to 30 months.[9] However, stratified analysis suggested that such interventions were effective when used in combination with in-person counseling (−1.93 kg; 95% CI: −2.71, −1.15 kg), rather than as a substitute for that (−0.19 kg, 95% CI: −0.87, 0.49 kg).

Twenty studies (15 RCTs, 5 quasi-experimental studies) evaluated Internet interventions and diet. Fourteen (10 RCTs and 4 quasi-experimental; 70%) found significant dietary improvements following the intervention. Effect sizes varied due to heterogeneity in dietary targets. As an example, the intake of fruit, the most common dietary target across studies, increased by ≈1 serving/day. Five of these 20 studies compared Internet intervention with higher-intensity conventional interventions: 2 showed significantly greater dietary effects in the Internet group, 2 showed both interventions were equally effective, and 1 showed no significant effect in either intervention arm.

Of 3 studies (2 RCTs, 1 quasi-experimental) evaluating mobile interventions and adiposity, 2 found significant reductions in adiposity.[14,15] Two RCTs assessed mobile-based interventions and fruit/vegetable intake; each found significant improvement (by 2 and 4 servings/day)[14,16] One of these compared a mobile intervention to an established conventional intervention, finding a greater effect in the mobile intervention group.[14] In a prior systematic review of 14 mobile trials (2007–2010) focused on text messages and lasting from 2 weeks to 12 months (Table 3), 11 studies

Table 3. Characteristics of Prior Systematic Reviews on Effectiveness of Information and Communication Technology Interventions to Improve Diet and Adiposity*

Author (Year)	No. of Studies (Years of Publication)	Setting	Intervention	Duration	Outcomes	Results
Stephens (2013)[11]	7 RCTs and quasi-experimental studies (2005–2010)	Primary care and community	Text messages and smartphone applications	4 weeks to 12 months	Adiposity and diet	Five (71%) studies reported statistically significant improvement in study outcomes
Kodama (2012)[9]	23 RCTs (<2011)	Primary care and community	Internet programs	3 to 30 months	Adiposity	Internet programs reduced weight only if used in combination with face-to-face counseling
Shaw (2012)[10]	14 RCTs and quasi-experimental studies (2007 and 2010)	Community	Text messages	2 weeks to 12 months	Adiposity and diet	11 (79%) studies reported statistically significant improvement in weight loss–related outcomes
Arem (2011)[12]	9 RCTs (2000–2009)	Primary care and online	Internet and computer programs	3 to 18 months	Adiposity	Interventions resulted in 1 to 4.9-kg weight loss
Norman (2007)[13]	36 RCTs and quasi-experimental studies (2000–2005)	Worksite, primary care, and community	Internet and computer programs	1 session to 12 months	Adiposity and diet	Intervention groups achieved significantly better results in 18 studies (50%)

RCTs indicates randomized controlled trials.
*Studies published before January 2011.

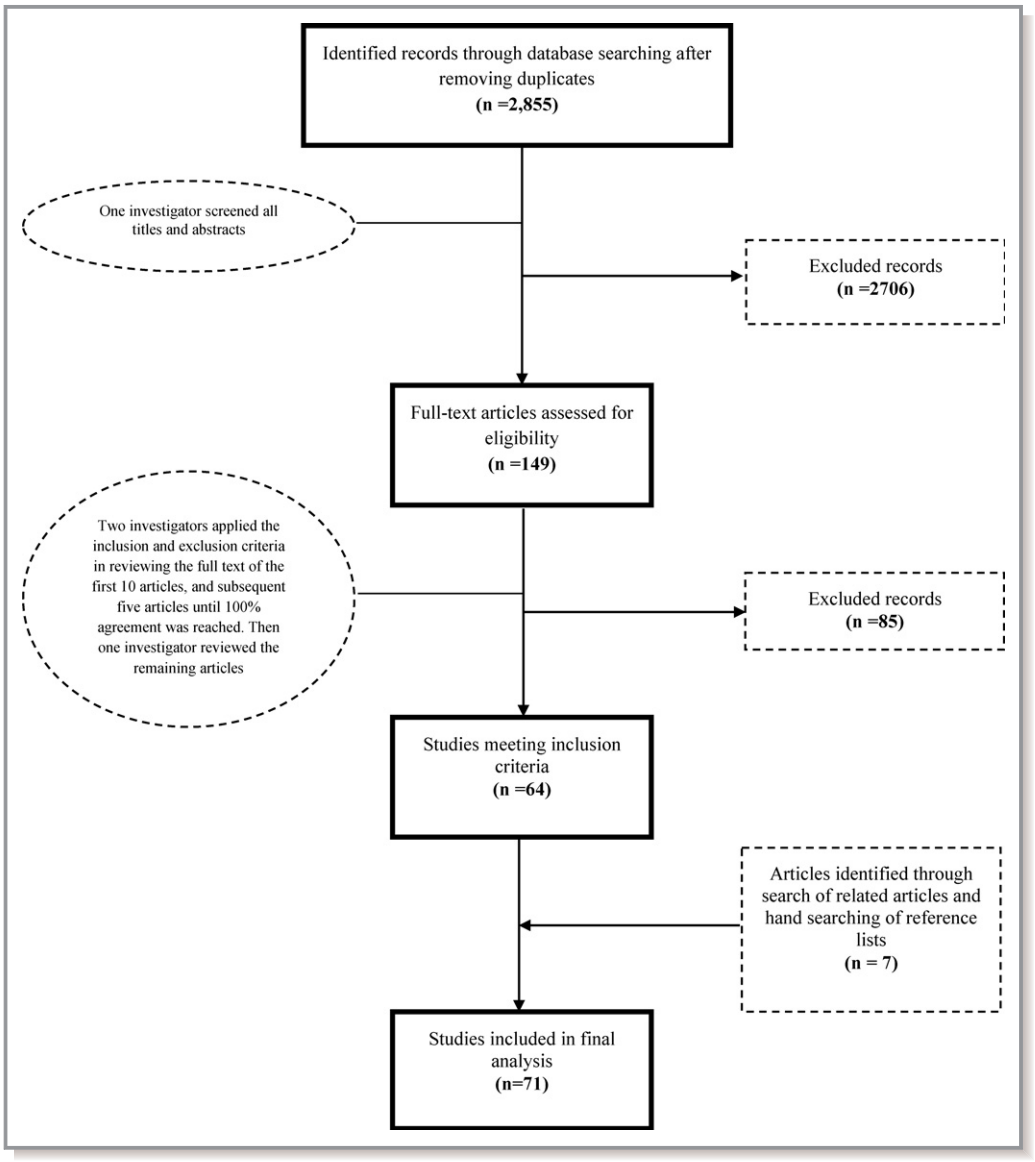

Figure 2. Screening and selection process of studies evaluating the effectiveness of information and communication technology to improve physical activity.

reported significant improvements in weight loss–related outcomes, whereas no significant change was reported in calorie intake or consumption of sugar-sweetened beverages in 4 trials evaluating diet.[10]

Fourteen RCTs and 2 quasi-experimental studies evaluated combined Internet/mobile interventions and adiposity. Most (13 of 16, 81%) reported significant reduction in adiposity. Of 6 studies that compared combined interventions with conventional interventions, 4 reported significantly higher effect on adiposity in the combined intervention group. Of 5 RCTs evaluating combined interventions and diet, 3 found significant improvement in dietary intake.[17–20] Of 2 studies assessing combined interventions and conventional interventions, 1 reported significantly higher effect on diet in the combined intervention group and 1 reported no effect in either intervention group.

Physical Activity

Of 2855 abstracts screened, 55 RCTs and 16 quasi-experimental studies were identified (Figure 2). Thirty-three studies were from the United States, 35 from other high-income countries (Australia, Austria, Belgium, Canada, Denmark, Finland, Germany, New Zealand, Norway, Scotland, Switzerland, The Netherlands, United Kingdom), and 3 from middle-income countries (Brazil, Taiwan). Studies were conducted in different settings including worksites, colleges, hospitals, churches, and in online communities. Study

Table 4. Effectiveness of Information and Communication Technology for Improving Physical Activity*†‡

Study Characteristics§	Internet‖	Sensors¶	Mobile#	Combined**
All studies				
No. of studies	33	19	6	10
No. of effective studies (%)	29 (88%)	15 (79%)	5 (83%)	7 (70%)
US studies				
No. of studies	18	6	1	4
No. of effective studies (%)	15 (83%)	4 (67%)	1 (100%)	4 (100%)
Design				
Randomized trials	29	13	5	5
Quasi-experimental studies	4	6	1	5
Duration				
<6 weeks	2	3	3	2
6 weeks to 6 months	27	15	3	8
>6 months	4	1	0	0
Recommendation				
Class of evidence	Class I	Class I	Class I	Class IIa
Level of evidence	A	A	A	A

*Studies were mostly conducted in predominantly female populations, constituting more than 60% of participants in 48 studies.
†In 49 studies, the mean age of participants was between 30 and 60 years while 10 studies had younger adults (<30 years) and 9 had older participants (>60 years).
‡Population sizes ranged from 54 to 4714. Eighteen studies had 50 to 99, 41 had 100 to 499, 4 had 500 to 999, and 8 had more than 1000 participants.
§Outcomes included different forms of physical activity (PA) such as leisure-time PA, moderate-to-vigorous PA, or walking; step count; and physical fitness.
‖Common features of Internet interventions included individually tailored messages, goal-setting, self-monitoring, individualized exercise plans, and an online forum where participants could interact. The interventions were mostly delivered as either an interactive Internet program or an Internet course providing structured information on improving physical activity.
¶Sensor-based interventions utilized only pedometers or accelerometers to promote physical activity. These interventions often included other features such as goal-setting, self-monitoring, individualized walking plans, supporting educational materials/courses, and group sessions.
#Mobile interventions utilized text messages and other features such as automated voice response system and smartphone applications.
**Interventions using at least 2 of the other categories (Internet, mobile phones, sensors) simultaneously.

durations ranged from 1 week to 5 years, with most lasting between 6 weeks and 6 months (Table 4).

Of the 33 Internet interventions (29 RCTs and 4 quasi-experimental), 29 (88%) reported significant improvement in physical activity (Table 4). Among RCTs, 25 of 29 (86%) found improved physical activity after the intervention. Of 2 RCTs comparing Internet interventions with conventional interventions, 1 reported significantly higher physical activity among participants receiving the Internet intervention, and 1 reported no significant improvement in either of the intervention groups.

The measure and magnitude of effect sizes varied across the studies reporting statistically significant effects. For example, in studies evaluating total duration of physical activity, the effect size ranged from 1.5 to 153 minutes/week. The difference of 153 minutes was reported in a 6-month study in which participants received immediate individually tailored computer-generated motivational messages after completing a monthly online questionnaire.[21] In studies evaluating frequency of physical activity, the effect sizes ranged from 1 to 1.2 days per week. In studies that used the odds ratio (OR) of meeting a physical activity recommendation as the effect measure, the effect sizes were between 1.3 and 1.5.

Nineteen studies (13 RCTs and 6 quasi-experimental studies) evaluated personal sensor (pedometer) interventions alone or along with educational materials, classes, or behavioral change techniques including goal setting. Of these, 15 (79%) reported significant positive effects. In these studies, the increase in step count from baseline was between 900 and 4500 steps/day. Examples of other types of effect sizes reported include the following: 97 minutes/week increase in leisure-time physical activity[22]; 32% reduction in percentage of sedentary participants[23]; 95 minutes/day reduction in sitting time[24]; and 2-day per week increase in walking days.[24] In general, studies that included behavioral change techniques were more effective. Of 5 RCTs that compared sensor interventions with conventional interventions, 2 reported significantly higher step counts and leisure walking with sensor interventions, 2 only found significant within-group improvements (from baseline) in physical activity, and 1 reported no significant within- or between-group difference in step count.

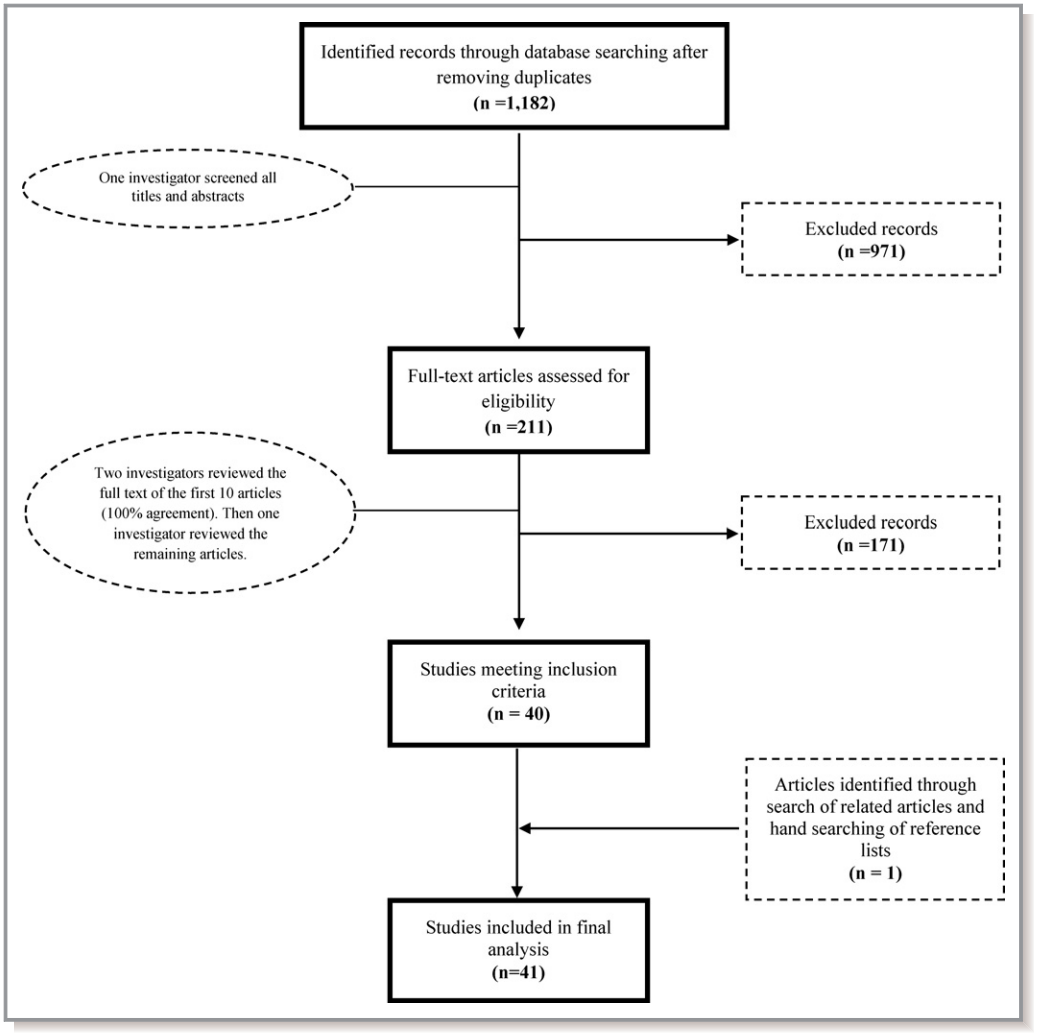

Figure 3. Screening and selection process of studies evaluating the effectiveness of information and communication technology for tobacco.

Six studies (5 RCTs and 1 quasi-experimental) assessed mobile interventions: 3 text message interventions, 2 smartphone applications, and 1 automated voice response. Of these, 2 of 3 utilizing text messages and all interventions involving smartphone applications and automated voice response were effective.

Five RCTs and 5 quasi-experimental studies evaluated combined interventions (eg, Internet and sensors). Of these, 7 (70%) demonstrated significant improvements: 5 reported increased step count (1000–2600 steps/day); 1, increased 7-day walking (90 minutes/week)[25]; 1, increased odds of meeting physical activity recommendations (OR: 1.7).[26]

Tobacco

Of 1182 screened articles, 41 met inclusion criteria (Figure 3): 17 from the United States, 22 from other high-income countries (United Kingdom, Australia, Germany, Norway, New Zealand, The Netherlands, Switzerland), and 2 from middle-income nations (Turkey, Thailand). Study settings included worksites, academic institutions, communities, general clinical practice, and online populations. Primary outcomes were generally the prevalence of abstinence (eg, 7- or 30-day abstinence) at different time-points (eg, 1, 3, 6 months). Abstinence assessment methods ranged from self-report (N=29 studies) to breath carbon monoxide (N=6) and salivary cotinine (N=3). Duration of interventions ranged from 4 weeks to 2 years, with only 4 studies lasting longer than 1 year (Table 5).

Of 22 studies (21 RCTs, 1 prospective cohort) assessing Internet interventions, 17 reported significant increase in abstinence (Table 5). In studies reporting benefits, the OR for 7-day abstinence at 6 months ranged from 1.6 (95% CI: 1.1, 2.4) in an Internet worksite smoking cessation program in the United States to 2.7 (95% CI: 1.8, 4.0) utilizing email counseling in Switzerland. The OR did not consistently vary

Table 5. Effectiveness of Information and Communication Technology for Smoking Cessation*†‡

Study Characteristics	Mobile§	Internet‖	Computer¶	Combined#
All studies				
No. of studies	7	22	8	3
No. of effective studies (%)	2 (29%)	17 (77%)	4 (50%)	1 (33%)
US studies				
No. of studies	0	11	4	2
No. of effective studies (%)	0	9 (82%)	2 (50%)	1 (50%)
Design				
Randomized trials	6	21	8	2
Quasi-experimental	1	0	0	1
Prospective cohort	0	1	0	0
Duration				
<3 months	3	9	2	2
3 to 6 months	4	0	1	1
>6 months	0	13	5	0
Recommendation				
Class of evidence	Class IIb	Class I	Class IIa	Class IIb
Level of evidence	A	A	A	B

*About half (N=21) of studies included predominantly male participants; other studies had mixed sex populations.
†In 32 studies, the mean age of participants was between 30 and 60 years and, in 9 studies, the mean age of participants was less than 30 years.
‡Sample sizes ranged from 68 to 6451. Four studies had 50 to 99, 14 had 100 to 499, 5 had 500 to 999, and 18 studies had more than 1000 participants.
§Text messages, cellphone calls, or smartphone apps.
‖Website and email messages.
¶Computer-based software.
#Interventions using at least 2 of the other categories (Internet, mobile phones, computer software) simultaneously.

with longer durations of follow-up, either within or between studies. Of 6 studies comparing Internet interventions with conventional interventions, 4 reported significantly greater effect in an Internet group and 2 reported significant within-group changes with no significant difference between intervention arms.

Seven studies (6 RCTs, 1 quasi-experimental) evaluated mobile phone text-messaging smoking cessation programs. Of these, only 2 (29%) reported benefits with OR of 7-day abstinence ranging from 1.3 (95% CI: 1.2, 1.5) in a UK-based study to 2.2 (95% CI: 1.8, 2.7) in a study conducted in New Zealand. We did not identify any study comparing mobile interventions with conventional interventions.

Of 8 RCTs-assessed computer-based software, 4 (50%) reported significant improvements in abstinence, with ORs ranging from 1.1 to 1.6. The intervention generally included a questionnaire to assess smoking behavior, which was then used as a basis to provide tailored smoking cessation advice.

Excessive Alcohol Use

Of 1015 abstracts screened, 41 RCTs and 6 quasi-experimental studies met inclusion criteria (Figure 4). All studies were conducted in high-income Western countries including the United States (N=21), The Netherlands (n=7), United Kingdom (n=5), Canada (n=3), New Zealand (n=3), Sweden (n=2), Germany (n=2), Australia, Switzerland, Finland, and Denmark. More than half (n=27) were carried out in universities, colleges, or schools; and the remaining in primary care, workplace, or other community settings. The study population mostly included adults with unhealthy patterns of drinking. Most studies evaluated the effect of a single session intervention consisting of assessment and personalized feedback over a follow-up period of 1 week to 2 years (Table 6).

Of 47 studies (41 RCTs, 6 quasi-experimental) evaluating Internet interventions, 39 (34%) reported significant decrease in alcohol use (Table 6). Of 41 RCTs, 34 (83%) reported statistically significant benefits. The only trial that compared Internet versus conventional intervention reported significant within-group improvement in heavy drinking days at 3 and 6 months, but no significant between-group differences.

The type and magnitude of effect sizes varied across the studies reporting reductions in alcohol use. Examples included reductions of 63% in weekly alcohol use after a 3-month intervention[27]; 50% in heavy drinking days at

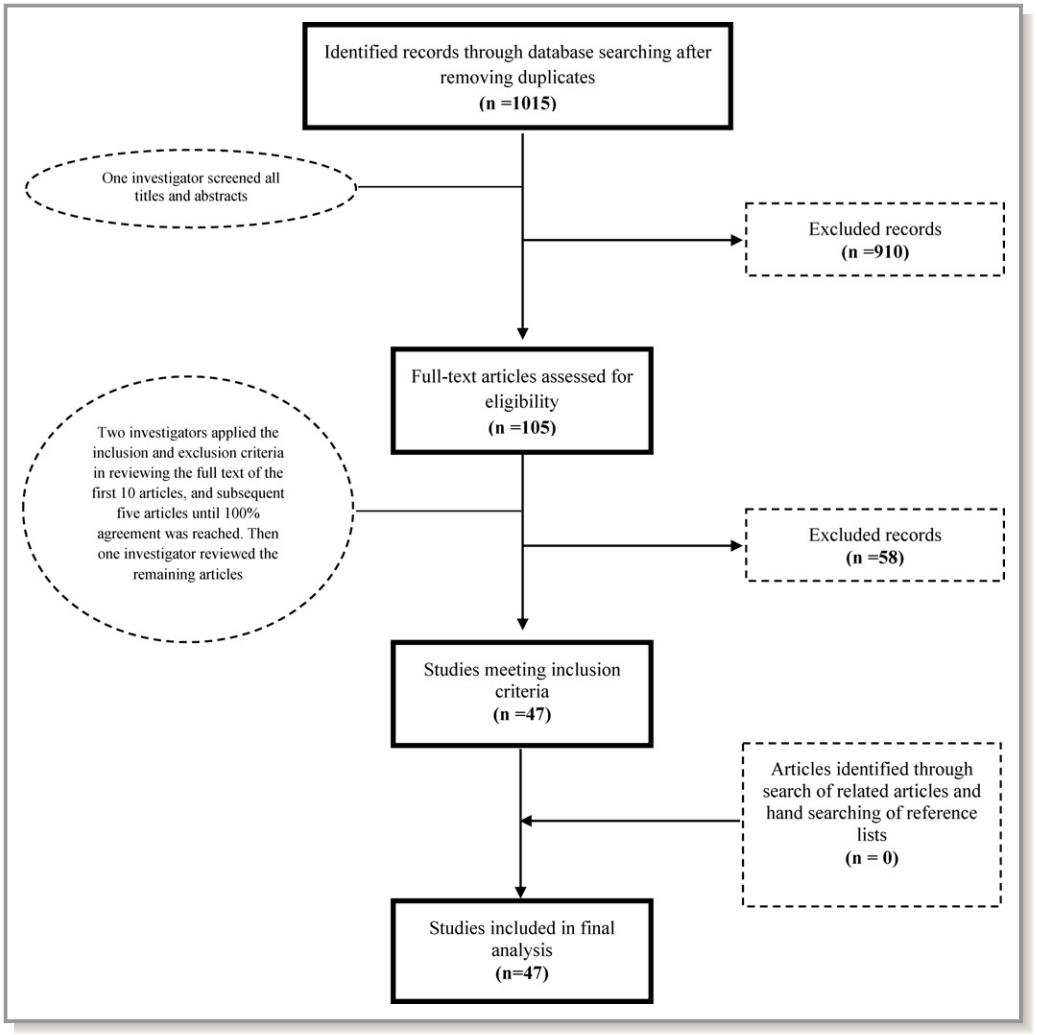

Figure 4. Screening and selection process of studies evaluating the effectiveness of information and communication technology to improve alcohol use.

6-month follow-up among veterans screening positive for alcohol misuse[28]; 7 drinks in mean weekly drinking at 3-month follow-up among risky drinkers[29]; 16% in heavy episodic drinking at 1-month follow-up relative to controls[30]; and 10 units (100 mL ethanol) in weekly alcohol use at 7-week follow-up.[31] In studies finding benefits and reporting compliance with drinking recommendation as an outcome, the OR for drinking within the recommended limit ranged from 1.7 to 3.7.

Discussion

We systematically investigated, synthesized, and graded scientific evidence for effectiveness of information and communication technology to improve lifestyle. Our results support the effectiveness of Internet interventions to improve diet, physical activity, adiposity, tobacco, and excess alcohol. Mobile interventions were also found to be effective for improving physical activity and adiposity. Our comprehensive review also identified several important research gaps and potential directions for future research.

We found that evidence on effectiveness of information and communication technologies mainly came from short-term (<6 months) experimental studies, with far less data on long-term effectiveness or sustainability. Additionally, most studies were in high-income countries and largely included volunteers who were generally more motivated and more educated than the general public. This could limit generalizability of findings, highlighting the need for more evidence from studies with longer duration of follow-up (>1 year), from population subgroups (eg, less educated, elderly) and from developing countries.

Our review also highlights operational challenges in evaluating the effectiveness of Internet and mobile interventions. Low adherence rate was a major challenge in most of the studies, in particular in studies with longer durations of follow-up (>3 months). While, due to heterogeneity in definition of adherence, the direct comparison of adherence rates

Table 6. Effectiveness of Information and Communication Technology for Reducing Alcohol Use*†‡

Study Characteristics§	Internet‖
All studies	
No. of studies	47
No. of effective studies (%)	39 (83%)
US studies	
No. of studies	21
No. of effective studies (%)	18 (86%)
Design	
RCTs	41
Quasi-experimental studies	6
Cohort study	0
Duration	
<6 weeks	13
6 weeks to 6 months	26
>6 months	8
Recommendation	
Class of evidence	I
Level of evidence	A

RCTs indicates randomized controlled trials.
*Women had more representation in 12 studies while men had more representation in 8 studies.
†The mean age of participants was less than 30 years in 33 studies and between 30 and 60 years in 14 studies.
‡The study population size ranged from 104 to 10 000. Twenty-one studies had 100 to 499, 11 had 500 to 999, and 15 had 1000 or more participants.
§Outcomes: alcohol use (frequency and quantity), binge drinking, estimated blood alcohol concentration, alcohol dependency, and Alcohol Use Disorder Identification Test scores.
‖The interventions mostly consisted of an assessment of the participant's drinking behavior, which was then used to provide a personalized normative feedback, comparing the participant's drinking to that of a reference population. Some interventions were Internet courses designed for college students.

across studies was not possible, the majority of studies consistently showed a significant decline in adherence over time. Similarly, heterogeneity in the content, intensity, behavioral targets, and duration of interventions made it difficult to directly compare results across studies, perform quantitative meta-analysis, or identify specific promising features of individual interventions. Additionally, few studies assessed their intervention's outreach or coverage.

We found that using evidence-based behavioral change strategies could increase the effectiveness of Internet and mobile interventions. For example, in studies of the diet and adiposity, interventions were more effective if adopting multiple modes of communication, using tailored messages, and integrating goal-setting and self-monitoring. Similarly, in studies of physical activity, developing the content of Internet interventions based on psychological theories of behavioral change increased the effect of the intervention and retention of participants. We also found that interaction with providers could increase the success rate of the intervention. For example, in studies of smoking cessation, the interventions tended to be more effective if they included a direct interaction between smoker and healthcare provider. These findings could inform development of novel Internet and mobile interventions that are more effective and have a greater adherence rate. Many existing policies aiming to improve population lifestyle behaviors have focused on conventional strategies such as mass media campaigns, environment changes, and school-based programs.[4] In comparison, use of novel information and communication technologies that provide individually tailored data has grown more organically (for example, from private industry and consumer demand, with little systematic use or evaluation). There is growing recognition of the potentials of such interventions. For example, the US National Physical Activity Plan includes media strategies that encourage stakeholders to incorporate such emerging technologies into programs.[32] The US Community Preventive Services Task Force recently recommended use of a computer-based Electronic Screening and Brief Intervention (e-SBI) for addressing excess alcohol.[33] Yet, considering the strength of the evidence, our findings suggest that the application and testing of novel information and communication technologies should be greatly expanded.

Potential limitations should be considered. Application of Internet and mobile for health promotion and NCD prevention is rapidly growing, and this review might not have captured all the studies that have been published in this field. Although our findings suggest that Internet and mobile interventions are promising for lifestyle modification, the effect sizes of these interventions depend on multiple factors (eg, the content and components of the intervention) and could be widely varied across studies and over time. The present study only evaluated the efficacy of Internet and mobile interventions for primary prevention of NCDs and did not assess their effect in patients with chronic disease, highlighting the need for similar evaluation of evidence in this population.

In conclusion, our systematic review supports the effectiveness of Internet and mobile interventions to improve lifestyle and reduce NCD risk factors. Our findings also highlight the need for greater evaluation of long-term effectiveness, sustainability, and assessment of utility in more diverse population subgroups.

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Disclosures

None.

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Supplemental Material

Data S1: PubMed search query for diet and adiposity

Intervention Query

("health technology"[tiab] OR "mobile technology"[tiab] OR "e-learning"[tiab] OR "mobile health"[tiab] OR "mhealth"[tiab] OR "cellular phone"[MeSH] OR "cell phone"[tiab] OR "mobile phone"[tiab] OR "mobile device"[tiab] OR "smartphone"[tiab] OR "personal digital assistant"[tiab] OR "text messaging"[MeSH] OR "text message"[tiab] OR "email"[tiab] OR "ehealth"[tiab] OR "Internet"[MeSH] OR "Internet-based"[tiab] OR "web-based"[tiab] OR "social media"[MeSH] OR "social media"[tiab] OR "information technology"[tiab] OR "communication technology"[tiab] OR "health communication"[tiab])

Outcome Query (Diet and Obesity)

("diet"[MeSH] OR "diet$"[tiab] OR "food"[tiab] OR "foods"[tiab] OR "nutrition$"[tiab] OR "nutrient$"[tiab] OR "nutrient"[tiab] OR "food habits"[MeSH] OR "food habit$"[tiab] OR "dietary behavior"[tiab] OR "energy intake"[tiab] OR "Food and Beverages"[MeSH] OR "fruit"[tiab] OR "fruits"[tiab] OR "vegetable"[tiab] OR "vegetables"[tiab] OR "beans"[tiab] OR "legumes"[tiab] OR "whole grains"[tiab] OR "nuts"[tiab] OR "beverage"[tiab] OR "beverages"[tiab] OR "soda"[tiab] OR "juice"[tiab] OR "sugar-sweetened beverage"[tiab] OR "SSB"[tiab] OR "milk"[tiab] OR "seafood"[tiab] OR "meat"[tiab] OR "fast foods"[MeSH] OR "junk food"[tiab] OR "dairy"[tiab] OR "candy"[tiab] OR "Fatty Acids"[MeSH] OR "fat"[tiab] OR "fats"[tiab] OR "fatty acids"[tiab] OR "oil"[tiab] OR "oils"[tiab] OR "saturated"[tiab] OR "unsaturated"[tiab] OR "trans fatty"[tiab] OR "trans fat"[tiab] OR "omega-3"[tiab] OR "sodium, dietary"[MeSH] OR "Sodium Chloride"[MeSH] OR "sodium"[tiab] OR "salt"[tiab] OR "soy foods"[MeSH] OR "sugar"[tiab] OR "carbohydrates"[MeSH] OR "cholesterol, dietary"[MeSH] OR "dietary fiber"[MeSH] OR "dietary calcium"[tiab] OR "dietary quality"[tiab] OR "dietary pattern"[tiab] OR "obesity"[MeSH] OR "obesity"[tiab] OR "body weight"[MeSH] OR "weight"[tiab] OR "weight loss"[tiab] OR "weight maintenance"[tiab] OR "weight management"[tiab] OR "body mass index"[MeSH] OR "BMI"[tiab] OR "obese"[tiab] OR "overweight"[MeSH] OR "overweight"[tiab] OR "adiposity"[MeSH] OR "adiposity"[tiab] OR "weight reduction programs"[MeSH] OR "diet, reducing"[MeSH])

NOT Query

("Soil"[MeSH] OR "Soil"[tiab] OR "Spectrometry"[tiab] OR "Antibiotic"[tiab] OR "Antibiotics"[tiab] OR "Chromatography"[MeSH] OR "Chromatography"[tiab] OR "Pollution"[tiab] OR "Pathology"[MeSH] OR "Pathology"[tiab] OR "Phosphate"[tiab] OR "Phosphates"[MeSH] OR "Gene"[tiab] OR "Genes"[MeSH] OR "Haplotype"[tiab] OR "Haplotypes"[MeSH] OR "Poison"[tiab] OR "Poisons"[MeSH] OR "Toxin"[tiab] OR "Toxins"[tiab] OR "Cattle"[MeSH] OR "Cattle"[tiab] OR "Livestock"[MeSH] OR "Livestock"[tiab] OR "Receptor"[tiab] OR "Allele"[tiab] OR "Alleles"[MeSH] OR "Polymorphism"[tiab] OR "Molecule"[tiab] OR "Molecular"[tiab] OR "DNA"[MeSH] OR "DNA"[tiab] OR "Virus"[tiab] OR "viruses"[MeSH] OR "Microbiology"[MeSH] OR "Microbiology"[tiab])

Abstracts identified: 3602
Date of search: November 2013

Data S2: PubMed search query for physical activity

Intervention Query

("health technology"[tiab] OR "mobile technology"[tiab] OR "e-learning"[tiab] OR "mobile health"[tiab] OR "mhealth"[tiab] OR "cellular phone"[MeSH] OR "cell phone"[tiab] OR "mobile phone"[tiab] OR "mobile device"[tiab] OR "smartphone"[tiab] OR "personal digital assistant"[tiab] OR "text messaging"[MeSH] OR "text message"[tiab] OR "email"[tiab] OR "ehealth"[tiab] OR "Internet"[MeSH] OR "Internet-based"[tiab] OR "web-based"[tiab] OR "social media"[MeSH] OR "social media"[tiab] OR "information technology"[tiab] OR "communication technology"[tiab] OR "health communication"[tiab] OR "pedometer"[tiab])

Outcome Query

("Exercise" [MeSH] OR "Exercise" [tiab] OR "Physical Fitness"[MeSH] OR "Fitness"[tiab] OR "physical activity" [tiab] OR "Walking" [MeSH] OR "Walking" [tiab] OR "running" [MeSH] OR "running" [tiab] OR "jogging" [tiab] OR "biking" [tiab] OR "bicycling"[tiab])

NOT

("Soil"[MeSH] OR "Soil"[tiab] OR "Spectrometry"[tiab] OR "Antibiotic"[tiab] OR "Antibiotics"[tiab] OR "Chromatography"[MeSH] OR "Chromatography"[tiab] OR "Pollution"[tiab] OR "Pathology"[MeSH] OR "Pathology"[tiab] OR "Phosphate"[tiab] OR "Phosphates"[MeSH] OR "Gene"[tiab] OR "Genes"[MeSH] OR "Haplotype"[tiab] OR "Haplotypes"[MeSH] OR "Poison"[tiab] OR "Poisons"[MeSH] OR "Toxin"[tiab] OR "Toxins"[tiab] OR "Cattle"[MeSH] OR "Cattle"[tiab] OR "Livestock"[MeSH] OR "Livestock"[tiab] OR "Receptor"[tiab] OR "Allele"[tiab] OR "Alleles"[MeSH] OR "Polymorphism"[tiab] OR "Molecule"[tiab] OR "Molecular"[tiab] OR "DNA"[MeSH] OR "DNA"[tiab] OR "Virus"[tiab] OR "viruses"[MeSH] OR "Microbiology"[MeSH] OR "Microbiology"[tiab])

Abstracts identified: 2855
Date of search: November 2013

Data S3: PubMed search query for tobacco

Intervention Query

("health technology"[tiab] OR "mobile technology"[tiab] OR "e-learning"[tiab] OR "mobile health"[tiab] OR "mhealth"[tiab] OR "cellular phone"[MeSH] OR "cell phone"[tiab] OR "mobile phone"[tiab] OR "mobile device"[tiab] OR "smartphone"[tiab] OR "personal digital assistant"[tiab] OR "text messaging"[MeSH] OR "text message"[tiab] OR "email"[tiab] OR "ehealth"[tiab] OR "Internet"[MeSH] OR "Internet-based"[tiab] OR "web-based"[tiab] OR "social media"[MeSH] OR "social media"[tiab] OR "information technology"[tiab] OR "communication technology"[tiab] OR "health communication"[tiab])

Outcome Query

("smoking" [MeSH] OR "smoking$" [tiab] OR "cigarette smoking" [MeSH] OR "cigarette smoking" [tiab] OR "cigarette smoking$" [tiab] OR "tobacco" [MeSH] OR "tobacco" [tiab] OR "tobacco$" [tiab])

NOT Query

("Soil"[MeSH] OR "Soil"[tiab] OR "Spectrometry"[tiab] OR "Antibiotic"[tiab] OR "Antibiotics"[tiab] OR "Chromatography"[MeSH] OR "Chromatography"[tiab] OR "Pollution"[tiab] OR "Pathology"[MeSH] OR "Pathology"[tiab] OR "Phosphate"[tiab] OR "Phosphates"[MeSH] OR "Gene"[tiab] OR "Genes"[MeSH] OR "Haplotype"[tiab] OR "Haplotypes"[MeSH] OR "Poison"[tiab] OR "Poisons"[MeSH] OR "Toxin"[tiab] OR "Toxins"[tiab] OR "Cattle"[MeSH] OR "Cattle"[tiab] OR "Livestock"[MeSH] OR "Livestock"[tiab] OR "Receptor"[tiab] OR "Allele"[tiab] OR "Alleles"[MeSH] OR "Polymorphism"[tiab] OR "Molecule"[tiab] OR "Molecular"[tiab] OR "DNA"[MeSH] OR "DNA"[tiab] OR "Virus"[tiab] OR "viruses"[MeSH] OR "Microbiology"[MeSH] OR "Microbiology"[tiab])

Abstracts identified: 1182
Date of search: November 2013

Data S4: PubMed search query for alcohol use

Intervention Query
("health technology"[tiab] OR "mobile technology"[tiab] OR "e-learning"[tiab] OR "mobile health"[tiab] OR "mhealth"[tiab] OR "cellular phone"[MeSH] OR "cell phone"[tiab] OR "mobile phone"[tiab] OR "mobile device"[tiab] OR "smartphone"[tiab] OR "personal digital assistant"[tiab] OR "text messaging"[MeSH] OR "text message"[tiab] OR "email"[tiab] OR "ehealth"[tiab] OR "Internet"[MeSH] OR "Internet-based"[tiab] OR "web-based"[tiab] OR "social media"[MeSH] OR "social media"[tiab] OR "information technology"[tiab] OR "communication technology"[tiab] OR "health communication"[tiab])

Outcome Query
("alcohol" [tiab] OR "Alcohol Drinking"[MeSH] OR "beer"[MeSH] OR "beer"[tiab] OR "drink$"[tiab] OR "alcohol intake"[tiab] OR "alcohol use"[tiab])

NOT Query
("Soil"[MeSH] OR "Soil"[tiab] OR "Spectrometry"[tiab] OR "Antibiotic"[tiab] OR "Antibiotics"[tiab] OR "Chromatography"[MeSH] OR "Chromatography"[tiab] OR "Pollution"[tiab] OR "Pathology"[MeSH] OR "Pathology"[tiab] OR "Phosphate"[tiab] OR "Phosphates"[MeSH] OR "Gene"[tiab] OR "Genes"[MeSH] OR "Haplotype"[tiab] OR "Haplotypes"[MeSH] OR "Poison"[tiab] OR "Poisons"[MeSH] OR "Toxin"[tiab] OR "Toxins"[tiab] OR "Cattle"[MeSH] OR "Cattle"[tiab] OR "Livestock"[MeSH] OR "Livestock"[tiab] OR "Receptor"[tiab] OR "Allele"[tiab] OR "Alleles"[MeSH] OR "Polymorphism"[tiab] OR "Molecule"[tiab] OR "Molecular"[tiab] OR "DNA"[MeSH] OR "DNA"[tiab] OR "Virus"[tiab] OR "viruses"[MeSH] OR "Microbiology"[MeSH] OR "Microbiology"[tiab])

Abstracts identified: 1015
Date of search: November 2013