A systematic review of technology-based interventions for unintentional injury prevention education and behaviour change

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ABSTRACT

Objective The aims of this literature review are to (1) summarise how computer and mobile technology-based health behaviour change applications have been evaluated in unintentional injury prevention, (2) describe how these successes can be applied to injury-prevention programmes in the future and (3) identify research gaps.

Methods Studies included in this systematic review were education and behaviour change intervention trials and programme evaluations in which the intervention was delivered by either a computer or mobile technology and addressed an unintentional injury prevention topic. Articles were limited to those published in English and after 1990.

Results Among the 44 technology-based injury-prevention studies included in this review, 16 studies evaluated locally hosted software programmes, 4 studies offered kiosk-based programmes, 11 evaluated remotely hosted internet programmes, 2 studies used mobile technology or portable devices and 11 studies evaluated virtual-reality interventions. Locally hosted software programmes and remotely hosted internet programmes consistently increased knowledge and behaviours. Kiosk programmes showed evidence of modest knowledge and behaviour gains. Both programmes using mobile technology improved behaviours. Virtual-reality programmes consistently improved behaviours, but there were little gains in knowledge. No studies evaluated text-messaging programmes dedicated to injury prevention.

Conclusions There is much potential for computer-based programmes to be used for injury-prevention behaviour change. The reviewed studies provide evidence that computer-based communication is effective in conveying information and influencing how participants think about an injury topic and adopt safety behaviours.

INTRODUCTION

Unintentional injuries continue to be the leading cause of death for ages 1–44 in the USA,[1] despite the growing number of effective prevention strategies. Challenges remain for the injury-prevention field to increase adoption of preventive behaviours. Unintentional injury poses particular challenges for prevention as many preventive strategies rely on behaviour change. For example, although booster seats have been shown effective in reducing motor-vehicle-incident-related injuries,[2] use rates of booster seats remain low.[3] Behaviour change plays a vital role to any unintentional injury prevention strategy, and numerous approaches to increasing the adoption of safety behaviours have been tested with mixed success.[4–9] Strategies have included tailored education, instructor-led classes and provision of safety equipment.

A growing number of public health programmes are making use of technology such as computers, mobile devices, and the internet to deliver interventions. Emerging terms such as 'e-health' and 'm-health' are broadly defined with little consensus.[10] The most frequently cited definition of e-health is '… health services and information delivered or enhanced through the internet and related technologies'.[11] M-health is a subset of e-health, commonly referring to 'medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants and other wireless devices'.[12]

Enthusiasm for e-health and m-health is understandable given the opportunities for efficient and cost-effective delivery of public health programmes. Computer algorithms can easily personalise and tailor health education; email and text messages provide potential for ongoing two-way communication between patients and professionals, and increased ownership of personal computers and mobile phones allows users to continue interacting with the programme at home or on-the-go. Such technologies have been used successfully for behaviour change for smoking cessation,[13] weight loss,[14] diabetes management,[15] control of asthma[16] and mental-health screening,[17] and have been implemented in clinical[18] and community settings.[19 20] E-health and m-health interventions have shown promise for injury; there has been some success increasing balance and other physical health indicators that are associated with risk of falls.[21 22]

Computer and mobile technologies also can and should be effectively applied to address unintentional injury. The expansion and improvement of technology allows injury-prevention-programme planners to apply their creativity in new ways. The aim of this literature review is to summarise how computer-and-mobile-technology-based health behaviour change applications have been evaluated in unintentional injury prevention. Specifically, we addressed the following question: are computer-and-mobile-technology-based health behaviour change interventions effective in improving knowledge and behaviour for the prevention of unintentional injuries, compared with no intervention or alternate interventions, in adults and children?

METHODS

Study selection

Included studies were education and behaviour change intervention trials and programme evaluations, of any study design, in which the intervention, and/or control programme, was delivered by a computer processor. The processor may have been on a computer (including desktop computers, kiosk stations, internet-connected servers or virtual simulators), or a mobile device (such as a tablet or smart phone). Educational videos were not included, even if delivered via computer, as no computer processor was required to present the information. Studies were included if they addressed an unintentional injury prevention related topic, including interventions in which injury prevention was included among other topics. To be included in this synthesis, the study must have reported observed or self-reported safety behaviour, injury-prevention knowledge or injury outcomes. No requirements were specified on the study participants or length of follow-up. Studies included were limited to cognitive-behavioural interventions; computer programmes designed to improve physical health (eg, strength training for fall prevention) were not included. This literature has been recently summarised elsewhere.[21 22] Studies were excluded if computer use was only for data collection, the article reported a case study or if there was no injury-prevention component to the behaviour change or the outcome measured.

Search strategy

The search was conducted in six databases: Pubmed, Psychinfo, Cochrane, EMBASE, SCOPUS and Academic Search Complete. An initial search was conducted in February 2014. A weekly email alert was created to notify the research team if there were any newly published articles that matched their search query through March 2015. Review articles and the reference lists of included articles were examined for additional articles.

Search terms included: intervention or evaluation, injury prevention, safety, safety behaviour, accident prevention, bite, sting, cut, fall, burn, overexertion, poisoning, suffocate, motor vehicle, cyclist, bicycle, pedestrian, electronic mail, internet, computer tailoring, medical informatics, software, telephone, technology, wireless, mobile, text message, short message service, e-health, m-health, handheld, smartphone and social network. Articles were limited to those published in English and after 1990. A full list of search terms and detailed search strategy can be found in the online supplementary appendix.

An initial title screen of all of the articles that were identified was performed by one of the investigators (NR); another investigator (EO) reviewed the screen on a sample of 400 titles to verify the quality of the original title review. If a title appeared relevant, it was included. Once the initial title screen was completed, the two investigators (EO, NR) independently reviewed the abstracts to determine whether they met the inclusion criteria. If one investigator felt that an article met the inclusion criteria, the full-text article was retained at that time. Full-text manuscripts were independently reviewed by two investigators (EO and NR) to determine if they did in fact meet the inclusion criteria. Any disagreement about eligibility was resolved by discussion with a third author when necessary (WS), and consensus to include or exclude was reached.

Data abstraction and analysis

Study investigators used a data abstraction form to assist in the analysis of the retained articles. Information abstracted from the articles included the study design; technology used; target population and sample size; experimental and control conditions; knowledge, behaviour and injury outcomes; knowledge and behaviour change results; author takeaway messages; and strengths and limitations of the study. One investigator (NR) first abstracted the data for each study, and then a second investigator (EO) confirmed the accuracy of the information obtained. Studies were descriptively analysed by type of technology employed.

For ease of presentation and synthesis, we categorised the studies into five types: (1) locally hosted software programmes (delivered using a personal desktop or laptop computer including programmes on a CD-ROM); (2) kiosk-based programmes (programmes delivered on a kiosk computer station); (3) remotely hosted internet programme (programmes hosted on a remote server and delivered over the internet); (4) mobile technology and portable devices (programmes using mobile phones and tablets, including apps and text messaging, or portable devices to deliver an intervention); and (5) virtual-reality environments (programmes where participants are immersed in a computerised virtual environment). Virtual-reality programmes, usually tested in a laboratory setting, use a combination of advanced visual displays, commonly across multiple monitors and life-sized controls, such as a model car or a step to represent a sidewalk curb. A user interacts with the controls to react to the displayed images. Based on the user's response, a computer processor changes the display thereby providing immediate feedback to the user about their behaviour.

Assessment of quality and risk of bias

Studies included in the synthesis were assessed for methodological quality using a checklist designed for randomised and non-randomised studies.[23] This instrument has 27 criteria that assess the quality of reporting (10 items), external validity (13 items), internal validity (3 items) and power of a study (1 item). Two study investigators (NR and EO) independently assessed each article, with disagreements resolved by a third investigator (JZ). Only studies reporting results were assessed for quality; articles reporting only methods were not assessed.

RESULTS

Search results

Based on a review of titles, we reviewed 190 abstracts, and 99 full-text manuscripts were downloaded for review. Of these, 50 articles representing 44 studies met the inclusion criteria (see figure 1). Although our search included articles published since 1990, all eligible studies were published in 2002 or later. A total of 17 articles representing 16 studies were identified that delivered an intervention via locally hosted software, 6 articles described four kiosk-based programmes, 11 studies described in 12 articles evaluated remotely hosted internet-based programmes, 2 programmes used mobile technology or portable devices and 11 studies reported on virtual-reality environments (see online supplementary tables S1–S5).

Target population and injury topics

A majority of programmes, 24 of the 44, were designed for paediatric injury prevention: 14 programmes were designed to be used by children,[24–40] 7 programmes targeted parents,[41–50] 2 programmes provided anticipatory guidance training for paediatricians,[51 52] and 1 programme was designed for preschool staff.[53] Programmes designed for use by children primarily covered pedestrian safety,[24 25 30 32 34–36 38–40] fire safety[24 29 37] or dog-bite prevention[27 28 33] and included seven software programmes,[24–31] two internet programmes,[32 33] and five

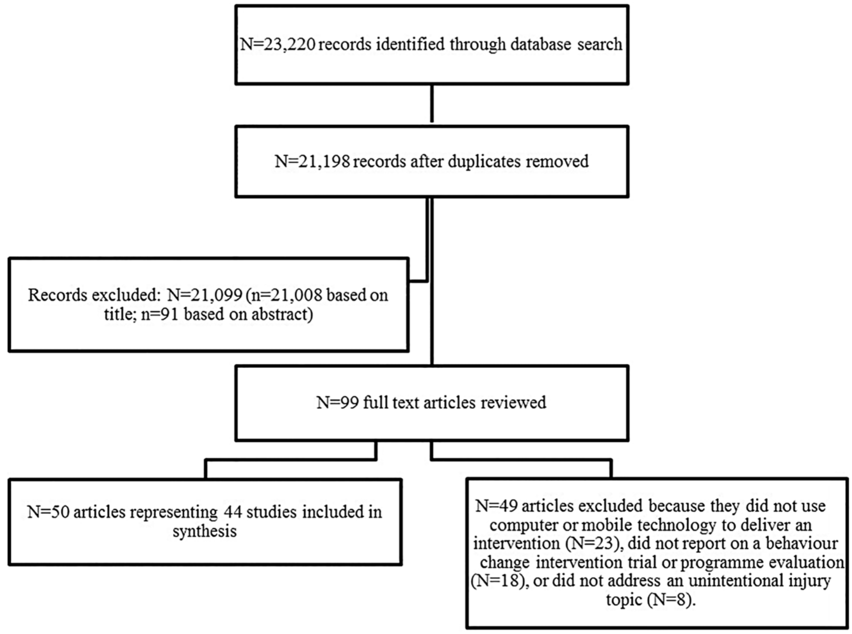

Figure 1 Flowchart of study selection.

programmes using virtual-reality settings.[34–40] All four kiosk programmes[42–47] targeted parents of young children in clinical settings and covered multiple injury topics (table 1).

The most frequently addressed safety behaviour was fire and burn safety, incorporated into 16 of the studies—three programmes for children,[24 29 37] seven programmes for parents,[41 42 44–50] and six programmes for clinicians or caregivers.[51 54–58] Each of the seven programmes designed for parents offered education about smoke alarms among a list of other injury-prevention topics. Driving behaviours were commonly the target of interventions directed at novice drivers (n=6)[59–64] and adult drivers (n=4).[65–68] Virtual-reality environments were the most commonly used technology, used by six of the programmes.[62–64 66–68] Child pedestrian injuries were the focus of eight studies, of which four used virtual-reality environments,[34–36 38–40] one used a remotely hosted internet programme,[32] and three used locally hosted software programmes.[24 25 30] Two studies addressed medication safety: one for adults receiving prescription pain relievers[69] and one for seniors taking multiple medications.[70]

Knowledge and behaviour change outcomes and results

Knowledge was the most commonly assessed outcome, measured in 23 of the studies. Observed behaviour was measured in 21 studies and self-reported behaviours or intentions were measured in 15 studies. One study measured falls,[71] and one used driving records to measure outcomes.[62] All but one virtual-reality programme[37] measured observed behaviours for outcome measures.

Considering the different types of technology, locally hosted software programmes and remotely hosted internet programmes consistently increased knowledge and behaviours. Although not all programmes observed differences between groups, most programmes observed differences within the intervention group. Kiosk programmes showed some evidence of increasing knowledge and behaviours; however, observed gains were modest. Although kiosk programmes increased knowledge or self-reported on select items, there was no difference between intervention and control participants on others. Parents receiving education delivered via health educator reported more improvement than parents receiving education from a kiosk.[45] Neither programme using mobile technology assessed knowledge; however, both improved behaviours. Virtual-reality programmes consistently improved behaviours, but there were little gains in knowledge.

Programmes designed for children were consistently effective in improving children's knowledge of the topic under study, and of the 11 that measured behavioural outcomes, 9 had positive outcomes. When parents were the intended audience, all of the interventions had uniformly positive outcomes for self-reported child-injury-prevention behaviours.[41–50] Among the eight programmes designed for older adults or their caretakers, those participating in the technology-based intervention demonstrated improved knowledge and injury-prevention behaviours.

Among programmes designed for drivers, all but one[63] reported positive behavioural outcomes. One intervention using GPS technology to monitor the driver's speed found that those drivers who received a monetary incentive for good driving behaviour significantly increased the percentage of time spent driving at or below the speed limit.[65]

Study design, quality of reporting and risk of bias

Randomised trials were widely used, with 30 of the 44 studies using that methodology. Sample sizes ranged from 5 participants in a case series up to 1292 parents in a randomised trial. Follow-up was conducted as late as 18 months postintervention, although most studies elected a 1 to 6-month follow-up period, and many tested participants immediately after the intervention.

A total of 46 of the 50 articles reported study results and were assessed for quality of reporting and risk of bias. Scores ranged from 9 to 25, with 15 of the 46 articles scoring 20 or above (see table 2). Most studies clearly reported the aims, measures, interventions and outcomes. Many were not adequately powered and few attempted to blind participants or those measuring the outcomes.

DISCUSSION

Overall, computer-and-mobile-technology-based interventions showed promise at increasing knowledge and behaviour for unintentional injury prevention. Virtual-reality programmes, in

Table 1 Studies organised by target population

First author (year)	Technology	Target population	Injury topic	Knowledge impact	Behaviour impact
Children					
Arbogast (2014)[34]	Virtual reality	Children in second and third grade	Pedestrian safety	Yes	Yes—observed
Bart (2008)[35]	Virtual reality	Children aged 7–11 years	Pedestrian safety	Not assessed	Yes—observed
Coles (2007)[24]	Software programme	Children aged 4–10 years diagnosed with FAS	Pedestrian safety or fire safety	Yes	No—observed
Glang (2005)[25]	Software programme	Children grades K-3	Pedestrian safety	Yes	Not assessed
McComas (2002)[36]	Virtual reality	Children in fourth grade to sixth grade in urban and suburban schools	Pedestrian safety	Not assessed	Yes—observed
McLaughlin (2010)[26]	Software programme	Children grades K-3	Bicycle safety	Yes	Yes—observed
Meints (2009)[27]	Software programme	Children aged 3–6 years	Dog-bite prevention	Yes	Not assessed
Padgett (2006)[37]	Virtual reality	Children 4–7 years diagnosed with FAS	Fire Safety	Not assessed	Yes—observed
Schwebel (2014)[32]	Internet programme	Children aged 7 and 8 years	Pedestrian safety	Not assessed	Yes—observed
Schwebel (2014)[39] Schwebel (2014)[40] Schwebel (2010)[38]	Virtual reality	Children aged 7 and 8 years	Pedestrian safety	Not assessed	Yes—observed
Schwebel (2012)[28] Morrongiello (2012)[29]	Software programme	Children aged 3.5–6 years with a dog at home	Dog-bite prevention or fire safety	Yes	No—observed
Schwebel (2015)[33]	Internet programme	Children aged 4–6 years	Dog safety	Not available	Not available
Thomson (2005)[30]	Software programme	Children aged 7, 9 and 11 years	Pedestrian safety	Not assessed	Yes—observed
Vanselow (2014)[31]	Software programme	5-year-old and 6-year-old children	Poison safety and lighter safety	Not assessed	Yes—observed
Parents					
Christakis (2006)[48]	Internet programme	Parents of children aged 0–11 years	SIDS; bicycle helmets; firearm storage; smoke detectors; car seats; hot water temperature among other non-injury topics	Not assessed	Yes—self report
Gielen (2007)[42] Shields (2012)[43] Shields (2013)[44]	Kiosk programme	Parents of children aged 4–66 months	Car seats, smoke alarms, and poison storage or development, sleep, dog bites and neighbourhood safety	Yes	Yes—self report
Gittelman (2014)[45]	Kiosk programme	Parent of children 1–14 years	Bicycle safety, child passenger safety, home fire safety and home safety	Not assessed	Yes—self report
McDonald (2005)[46]	Kiosk programme	Parents of children aged 6 weeks to 24 months	Smoke alarms, child passenger safety, poisons and falls	Yes	Yes—self report
Nansel (2002)[41]	Software programme	Parents of children aged 2–20	Car injury, burns, falls, poisoning and drowning	Not assessed	Yes—self-report
Nansel (2008)[47]	Kiosk programme	Parents of children aged 4 years and younger	Motor vehicle injuries, burns, falls, poisoning, airway obstruction and drowning	Not assessed	Yes—self report
van Beelen (2014)[49] van Beelen (2010)[50]	Internet programme	Parents of children aged 1–2 years	Fall, poisoning, drowning and burn prevention.	Not assessed	Yes—self report
Professionals Caring for Adults and Children					
Dingeldein (2012)[52]	Internet programme	Paediatric residents	Firearm injury prevention	Yes	Not assessed
Harrington (2002)[54]	Software programme	Life-care community facility staff	Fire safety	Yes	No—self-report
Harrington (2003)[55]	Software programme	Nursing facility staff	Fire safety	Yes	No—self-report
Harrington (2009)[56]	Software programme	Caregivers at residential board and care facilities	Fire emergency planning	Yes	Yes—self-report
Lehna (2011)[57]	Internet programme	Nurses	Burn prevention	Yes	Not assessed
Lehna (2014)[58]	Internet programme	Nurses and nursing students	Burn prevention	Yes	Not assessed
Sangvai (2012)[51]	Internet programme	Paediatric practitioners	Motor vehicle safety, bicycle safety, poison prevention, fire prevention, firearm safety	Yes	No—observed
Schwebel (2014)[53]	Internet programme	Staff at a preschool playground	Playground safety	Yes	Yes—self report
Walker (2003)[76]	Software programme	Staff members at board/care facility	Fall prevention	Yes	Yes—self report

Continued

Table 1 Continued

First author (year)	Technology	Target population	Injury topic	Knowledge impact	Behaviour impact
Drivers					
Akinwuntan (2005)[66]	Virtual reality	Adults with history of first stroke	Road traffic safety	Not assessed	Yes—observed
Ekeh (2013)[62]	Virtual reality	Novice drivers	Road traffic safety	Not assessed	Yes—Police involved offences
Horrey (2009)[59]	Software programme	Drivers aged 18–20 years	Distracted driving	Yes	Yes—observed
Ivancic (2000)[67]	Virtual reality	Adult drivers	Road traffic safety	Not assessed	Yes—observed
Lavallière (2012)[68]	Virtual reality	Older drivers aged 65–85 years	Road traffic safety	Not assessed	Yes—observed
Petzoldt (2013)[60]	Software programme	Novice drivers	Driving skills	Not assessed	Yes—observed
Pollatsek (2006)[61]	Software programme	High school students with learner's permit for 1–5 months	Road traffic safety	Not assessed	Yes—observed
Reagan (2013)[65]	Mobile technology or portable device	Licensed drivers	Speeding driving behaviour	Not assessed	Yes—observed
Rosenbloom (2014)[63]	Virtual reality	Novice drivers in Israel	Road traffic safety	No	No—observed
Wang (2010)[64]	Virtual reality	Novice drivers	Road traffic safety	Not assessed	Yes—observed
Adults					
Mansdorf (2009)[71]	Internet programme	Nursing home residents 59–95 years	Falls	Not assessed	Yes—observed
McCauley (2013)[69]	Internet programme	Adult outpatients	Prescription opioid misuse, safe use, storage and disposal of prescriptions	Yes	Yes—self report
Mira (2014)[70]	Mobile technology or portable device	Patients aged 65+ years on multiple medications	Safe medication use	Not assessed	Yes—self report
Sweeney (2003)[77]	Software programme	Older adults aged 55+ years at senior centre	Home safety	Yes	Not assessed

particular, consistently improved injury-prevention behaviours, as did programmes designed for children or drivers. More attention has been paid to the use of these technologies for fire safety behaviours than any other single topic. Fire safety particularly lends itself to computer and mobile applications because there is opportunity to demonstrate fire evacuation skills and provide tailored feedback; however, it may show greatest effectiveness in children with low baseline levels of knowledge. Pedestrian and driving behaviours were also popular injury topics for technology-based intervention. For these behaviours, virtual-reality environments were the technology of choice, and the results were almost uniformly positive. This may be because the interventions were focused on specific measurable skills that are best mastered through supervised practice. Simulator training offers the opportunity to practice skills in a risk-free environment. There was little information on how these interventions did or did not change participants' knowledge and beliefs (eg, risk perceptions), which could be important for maintaining behaviour change. There were also several examples of addressing multiple child injuries simultaneously using mostly kiosk-based interventions. Incorporating observations of behavioural outcomes would strengthen these studies.

Based on our review, the number and breadth of computer-and-mobile-technology-based injury-prevention programmes is promising. Our results support the potential for computer and mobile applications to influence behaviour change. Computer and mobile technology offers programme planners the ability to tailor health education to the individual and offer information about multiple topics via a single platform. Computer-and-mobile-technology-based education can complement written or verbal instruction from healthcare providers or be integrated into classroom instruction to supplement the injury-prevention information already being discussed. It also offers the opportunity for immediate feedback, which is particularly useful for learning new skills, such as crossing the street and preventing dog bites, as users can correct poor behaviours and receive immediate positive feedback. Computer and mobile technology also offer an efficient means to reach large segments of the population.[72] Of note for programme developers, users of injury-prevention programmes engage with the intervention a handful of times, in contrast to programmes designed for chronic health conditions, where users can track their progress over time.[14–16] Injury-prevention programmes of the future should take the successes described in the body of literature reviewed here and consider how to further advance the use of technology.

Among the studies included in this review, programmes used five types of technologies to deliver the intervention: locally hosted software programmes, kiosk-based programmes, remotely hosted internet programmes, mobile technology or portable devices and virtual-reality environments. These categories of computer-and-mobile-technology-based interventions have implications for dissemination and generalisability. Locally hosted programmes can only be accessed on the computer on which it resides and updates to the content require a user to update their software. Programmes hosted on remote, internet-connected servers must be accessed from an internet-connected device; however, programme administrators are able to update content without the user taking additional action.

We could find only one programme evaluating a smartphone app for injury prevention in the literature.[70] There are a number of apps that supply tools and information for injury prevention, and while some are produced by reputable groups such as the American Academy Pediatrics (*Car Seat Check*),

Table 2 Assessment of methodological quality and risk of bias

Reference	Reporting (Out of 10)	Internal validity (Out of 3)	External validity (Out of 13)	Power (Out of 1)	Total score Out of 27)
Locally hosted software programmes					
Coles *et al*[24]	8	1	10	0	19
Glang *et al*[25]	9	2	9	1	21
Harrington[54]	8	1	9	0	18
Harrington[55]	5	1	8	0	14
Harrington[56]	9	2	10	0	21
Horrey *et al*[59]	6	1	11	0	18
McLaughlin[26]	9	2	13	1	25
Meints[27]	9	0	7	1	17
Morrongiello *et al*[29]	8	1	10	0	19
Nansel *et al*[41]	9	2	10	1	22
Petzoldt *et al*[60]	6	0	7	0	13
Pollatsek *et al*[61]	8	0	9	0	17
Schwebel *et al*[28]	7	1	10	0	18
Sweeny[77]	7	1	10	1	19
Thomson *et al*[30]	5	1	7	0	13
Vanselow[31]	4	0	5	0	9
Walker[76]	8	1	9	0	18
Kiosk-based programmes					
Gielen *et al*[42]	9	3	12	1	25
Gittelman *et al*[45]	7	3	12	1	23
Shields *et al*[43]	9	3	12	1	25
Shields *et al*[44]	9	3	11	1	24
McDonald *et al*[46]	7	3	12	0	22
Nansel *et al*[47]	6	2	12	1	21
Remotely hosted internet programmes					
Christakis *et al*[48]	8	2	11	0	21
Dingledein *et al*[52]	7	3	7	0	17
Lehna *et al*[57]	6	1	6	0	13
Lehna[58]	7	1	6	0	14
Mandorf *et al*[71]	5	1	6	0	12
McCauley *et al*[69]	6	1	5	0	12
Sangvai *et al*[51]	6	2	10	0	18
Schwebel *et al*[32]	8	1	6	0	15
Schwebel *et al*[53]	7	2	7	0	16
van Beelen *et al*[49]	9	3	11	0	23
Programmes using mobile technology or portable device					
Mira *et al*[70]	9	2	11	1	23
Reagan *et al*[65]	7	1	8	0	16
Virtual-reality environments					
Akinwuntan *et al*[66]	9	2	10	1	22
Arbogast *et al*[34]	8	2	10	0	20
Bart *et al*[35]	6	1	10	0	17
Ekeh *et al*[62]	7	2	8	0	17
Ivancic[67]	6	0	6	0	12
Lavallière *et al*[68]	8	0	9	1	18
McComas *et al*[36]	4	1	9	0	14
Padgett *et al*[37]	7	1	7	0	15
Rosenbloom[63]	8	1	9	0	18
Schwebel *et al*[39]	7	1	7	0	15
Wang[64]	8	0	9	0	17

National Fire Protection Agency (*Sparky and The Case of the Missing Smoke Alarms*) and CDC (*Healthy Swimming*, *Ladder Safety*), others lack evidence supporting their content.[73] The lack of evaluation data leaves a gap in the literature as to whether and to what extent injury-prevention programmes can be effectively delivered via a smartphone app.

This review found no injury-prevention programmes delivered with text messaging; some broader text messaging programmes, such as *text4baby*,[74] have incorporated injury-prevention messages into their curriculum, but the effects of these injury-prevention messages have not been evaluated. Text messaging has been successful in health behaviour change,[75] although for behaviours that require ongoing change such that periodic reminders are appropriate to encourage maintenance of the behaviour change. It remains unclear if text messaging is a feasible media to deliver injury-prevention interventions. However, the point may be moot as technology continues to evolve and the prevalence of smartphone and tablet technology grows.

The reliance on self-reported behaviours was found to be prevalent. Self-reported behaviours are more at risk of social desirability or recall bias than observed behaviours. Technology may provide new measurement opportunities via telecommunications such as video and photos, and should be further explored for injury-prevention behaviours. Additionally, only two studies reported injury outcomes, which limit the inferences that can be drawn about the ability of these programmes to reduce the burden of injuries.

Finally, although some studies reported the theoretical underpinning of their interventions,[28 33 38–40 42 44 46 53 63] this information was not consistently included to allow us to make generalisations to the role of theory in changing the safety behaviours at issue in these studies. This leaves unanswered the underlying theories that explain which types of technology are best suited to which problems, audiences and contexts.

Limitations

A number of limitations apply to this review. It is possible that relevant articles were not included because they did not appear or were missed during the initial search. We used a comprehensive list of search terms and multiple databases, and reviewed citation lists of relevant manuscripts and review articles. It is also possible that articles were excluded erroneously during review. Strict inclusion criteria were developed and two investigators reviewed abstracts independently. Full texts were excluded only after consensus was reached. Additionally, only published articles available in English were included. No resources were available to translate articles in foreign languages and the breadth of search terms made searching databases of unpublished work such as dissertations and theses unfeasible.

Despite these limitations, the studies in this review provide evidence to the usefulness of computer-and-mobile-technology-based programmes for injury prevention behaviour change. Future injury-prevention programmes should take into consideration the advantages of computer algorithms to provide immediate, tailored feedback to the participant-based user interaction. Programmes may also want to consider the strengths of immersing the user in a simulated environment that provides the opportunity to practice safety behaviours. This is particularly advantageous for working with children learning new safety skills or drivers practicing hazard anticipation and visual inspection. More work is needed to better understand how, for whom, and under what circumstances such new skills are transferable to the real world environment and the extent to which population-level injury risk can be reduced.

CONCLUSION

There is much potential for computer-and-mobile-technology-based programmes to be used for injury prevention behaviour change. This review summarises 44 studies that have evaluated computer-and-mobile-technology-based injury-prevention programmes. Strong randomised controlled designs were commonly used; however, more work is needed to demonstrate their impact on observed behaviours and injury risk over longer follow-up periods. Newer technologies such as the use of smartphone and text messages and emerging injury problems such as distracted driving and unintentional poisoning provide important opportunities for future research.

What is already known on the subject

- There is much enthusiasm and potential for computer-and-mobile-technology-based health education and behaviour change across a wide range of health problems.
- Computer-and-mobile-technology-based technology offers programme planners the ability to tailor heath education to the individual, provide immediate feedback to the user and have ongoing communication with participants beyond classroom or clinic visits.

What this study adds

- This literature review summarises how computer-and-mobile-technology-based health behaviour change applications have been evaluated in unintentional injury prevention.
- The reviewed studies provide evidence that computer-based programmes are effective in conveying information and influencing how participants think about injury prevention and adopt safety behaviours.

Contributors EO, WS, EM, AG determined the search terms and inclusion criteria. The initial title search was conducted by NR. EO and NR reviewed the abstracts and abstracted the data. Quality assessment was completed by EO, NR and JZ. EO, WS, EM, MS and AG contributed to the analysis and interpretation of the data. All authors participated in drafting and revising the manuscript and final approval of the version to be published.

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