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Preventing Childhood Injuries: Improving Home Hazard Identification and Resolution Through Serious Game Simulation

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Abstract

Serious game simulations can improve engagement with intervention material, provide individualized scaffolding of new skills, circumvent literacy issues, and allow for skill practice in a simulated low-risk environment. Although serious games can offer flexibility, prevent frustration, and potentially reduce disengagement and attrition, most injury prevention programs for parents using technology do not include serious game simulation principles. This research examines Home Safety Hero, an innovative serious game simulation designed to promote understanding of home safety risks and how to resolve those risks. Injury risk for young children is an important problem and there is research evidence that children of parenting teens are at elevated risk. This preliminary research evaluates Home Safety Hero with parenting teens (n = 10; 100% female). Participants answered questionnaires on their demographics, technology ability and use, played all three phases of the simulation (i.e., Identification, Resolution, Distraction) four times, and answered questions about their engagement with the simulation and its content. Our findings indicate that parenting teens improved in the speed of identification, with and without distraction, and resolution of risks. The engagement data indicates that teens found the game engaging. Overall, teens became faster at spotting risks in the home and were quicker at acting when encountering risks. Home Safety Hero shows promise to improve home safety.

Keywords: Serious games; Simulation; Home injury; Injury prevention; Teens; Parenting teens

Public Significance Statements:

- Parenting teens improved their identification and resolution of home safety hazards in a simulated home environment.
- Parenting teens indicated that they were engaged with the simulation, and their engagement scores were higher than other studies using the same instrument.

- Parenting teens became significantly quicker at spotting risks in the home and that once identified, they were able to take action quicker to resolve risks.

Preventing Childhood Injuries: Improving Home Hazard Identification and Resolution through Serious Game Simulation

Over three million children in 2013 were seen in emergency rooms for unintentional home injuries, including falls, hits, cuts, burns, poisonings, near suffocations, and near drownings (Safe Kids Worldwide, 2015). Costs of hospital-treated nonfatal injuries in the United States for children was over $211 billion in 2013 (Zonfrillo et al., 2018). Childhood injuries are linked to substantial problems including long-term physical, cognitive, and emotional impairment (Rhodes & Iwashyna, 2007). Children in low-income, single-parent families and those in disadvantaged neighborhoods and ones whose parents are teens are at especially high risk (Kendrick et al., 2005; Strobino et al., 1992). Childhood injury and child neglect have common antecedents and potential causal factors (Peterson & Brown, 1994). Furthermore, inadequate supervision has been implicated in unintentional injures (Azar & Weinzierl, 2005; Landen et al., 2003; Morrongiello & Schell, 2010) and is frequently the reason for neglect (Azar et al., 2016a; Damashek et al., 2014; Ruiz-Casares et al., 2012), accounting for 75% of child protection cases (U.S. Department of Health and Human Services, 2017).

Prevention research is crucial for helping to reduce the incidence of childhood injuries. Such injuries occur most frequently within the household and adults' actions in the home play a strong role in their prevention. It is important for parents to learn about home safety in a low-risk environment that promotes autonomy and improves engagement. A simulation-based approach to injury prevention has the potential to provide parenting skills for reducing children's injuries in a low-risk environment. The purpose of this study was to describe the usefulness of an injury prevention serious game simulation (Home Safety Hero) by examining learning and engagement in a sample of parenting teens. We examined teens' reaction times to identify and resolve

hazards in Home Safety Hero and compared these reactions times across multiple plays of the game. Engagement with Home Safety Hero was also assessed.

Teen Parents and Injuries

The danger of injury and hospitalization among young children of teen parents is increased due to social isolation, lack of social support, and family disorganization and conflict (Agran et al., 2004; Kendrick et al., 2005; Rhodes & Iwashyna, 2007; Strobino et al., 1992). The risk of home injury is elevated in the children of teen parents compared with parents in other age groups (Jordan et al., 1993; Taylor et al., 1983), with the most common home injuries including falls, burns, and poisoning (Robertson et al., 2014). Limited supervision, lack of safety protective devices, and failure to remove safety hazards increase home injury risks for young children of teen parents (Robertson et al., 2014).

Many parenting teens learn about home safety from their own mothers (Bennett Murphy, 2001; Yuma-Guerrer et al., 2013). However, the quality and nature of grandmothers' advice regarding child safety practices varies as grandmothers often give outdated safety information and do not always provide safe injury prevention recommendations (Yuma Guerro et al., 2013). Furthermore, Bennett Murphy (2001) found that none of the teenaged mothers in their study received injury prevention information from primary care physicians or pediatricians. It is important to provide parenting teens with the best child safety practices.

Parental Injury Prevention Interventions

Parental injury prevention interventions have relied heavily on instruction presented in the form of pamphlets, in-person consultations, and internet instruction (Kendrick et al., 2007; Nansel et al., 2008; van Beelen et al., 2014). Many injury interventions are embedded in larger efforts to promote child well-being (e.g., Olds et al., 2007), making it difficult to determine what

caused the decrease in injuries. Current behavioral interventions delivered in the home suffer from high attrition and limited engagement and are often very resource intensive (Duggan et al., 2000). Home visiting programs show high attrition, especially in contexts where injury rates are highest, such as in parenting teens' homes. There is also evidence of negative provider biases toward targeted parent populations, which might be especially pronounced for parenting teens.

Injury prevention simulations. Technology has begun to be incorporated into injury prevention interventions to enhance service delivery, ensure fidelity, improve engagement, and extend reach. Previous studies have used computer software or web-based methods to tailor injury prevention and child safety information to parents and oftentimes these programs assessed one or a few hazard types (Nansel et al., 2002; Gielen et al., 2007; van Beelen et al., 2014). The potential for serious game simulations to tailor instruction has promise and the potential to overcome processes that might make learning and retention difficult (Kim et al., 2012). Serious game simulation refers to a game designed for something other than entertainment and involves principles that promote learning through rewarding progress towards achieving targeted goals, storylines to increase intrinsic motivation to engage with difficult learning content, repetition to reinforce learning, and realistic simulation settings that promote retention and generalization to everyday life (Cook et al., 2013; de Freitas & Liarokapis, 2011; Knowles et al., 2011; Mozelius, 2014; Whyte et al., 2015). Furthermore, serious game simulations have also been shown to be effective in improving adults' real-world behaviors such as improving learning of skills applicable to the healthcare profession (e.g., see Ricciardi & De Paolis, 2014 for review), sports (Wiemeyer, 2010), resilience among older adults (Yoon, 2014), cultural heritage (Mortara et al., 2013), and fire evacuation (Sacfung et al., 2014). . Serious game simulations are more cost effective in the long run, could reduce caseload burdens of professionals, diminish biases

associated with needing services, improve engagement, and extend the service reach of universal injury prevention (Azar et al., 2019; Anonymous, in preparation).

Serious game simulations may be especially useful for parenting teens who may have difficulty with (or lack access to) traditional in-person parent training and who might benefit from the tailored approach offered by such simulations. The use of serious game simulations might capitalize on teens' regular use of technology and serve as a relatable mechanism for providing parenting teens with information about child safety practices. To date, there have been some efforts to apply serious game technology to change the behaviors of older children, usually in the context of pedestrian and fire safety (Bart et al., 2008; McComas et al., 2002; Schwebel & McClure, 2010, 2014; Thomson et al., 2005). Therefore, the available literature does support the use of serious game technology to change the behaviors of older children and such technology might apply to increase injury prevention efforts among parenting teens. Due to concerns about the stigma attached to teenage pregnancy, teens might be reluctant to seek help from medical personnel who have the most up-to-date child safety practices. Serious gaming simulations have been effectively used in education purposes, and they might be useful for parenting teens to learn about injury prevention (Zhonggen, 2019).

Home Safety Hero

This work examined the potential of a serious game simulation, Home Safety Hero, to promote parenting teens' understanding of home safety risks and how to resolve those risks, as well as their engagement with the game. Home Safety Hero is a serious game simulation designed to help parents learn parenting skills in a safe environment without placing children at risk and promote parental autonomy in their learning (Azar et al., 2018). The simulation was

designed to compensate for low literacy through the inclusion of voiceovers and with learning that is contextualized (i.e., storyline; Azar et al., 2019).

Home Safety Hero was defined with the four main pillars of cognitive science as a framework for learning, including attention, active learning, feedback, and consolidation (Dehaene, 2013). Attention involves being alert during the learning process, with at least some medium level of arousal linked to knowledge gains (Baldi & Bucherelli, 2005). In serious game simulations, alertness should be maintained through graphics and sound. In Home Safety Hero, while exploring the rooms animations (e.g., steam on a kettle, moving water in the bathtub) are provided. Furthermore, human-voice voiceovers encourage and help train players on why risks are dangerous to young children, as well as includes music, and unique sounds for hazards to keep players engaged and alert. Engagement is important because it has positive effects on learning (Hamari et al., 2016).

The second aspect of the game's design was active learning, which engages learners in the process of learning through activities (Freeman et al., 2014). To fulfill this goal, the game must be interactive, which increases learning effectiveness (Sitzmann, 2011). Home Safety Hero encourages active learning through allowing players to navigate a virtual environment with interactive content; interactive content involves having hazards disappear when clicked, sounds, and animations for when hazards are clicked. Players become immersed with the content through the storyline that enmeshes them in the content as a "hero" trying to save children from dangerous hazards in the household. In addition, one portion of the game allows players to interact with answer selections and decided what "solution" they would want to perform to remove hazards.

Feedback is another element important to the development of serious games simulations (Pritchard et al., 1988). Home Safety Hero involves tailoring feedback based on the specific hazard and solutions. If an incorrect response or identification is selected, feedback is provided, and for some portions of the game, players can select another option once more. Furthermore, Home Safety Hero also includes progress bars, scoring, and achievements that further provide feedback to players (i.e., stars; Lameras, 2015).

The ability to have multiple training sessions through serious games simulations allow for shifts in memory consolidation (Wouters et al., 2013). Repetition and reinforcement are effective strategies for learning, as well as "spaced training" (Goverover et al., 2009; Vlach et al., 2008). Home Safety Hero involves repetition through multiple trials (i.e., various levels and phases) and via learning materials in different formats. In addition, the ability to pause and save allow for players to also engage in "spaced training".

The Present Study

For this study, research personnel visited teens three times over two weeks and teens played the game four times over the course of the intervention. The first aim of this translational study was to present preliminary findings from Home Safety Hero concerning the simulation's ability to promote learning through the identification of hazards, with or without distraction, and the resolution of those hazards. To address this aim, teens' reaction times to identify and resolve hazards were recorded by the game and compared across all four plays, while controlling for frequency of game play. We control for the frequency of game play to provide a clearer understanding of reaction times and changes in these times across multiple plays of Home Safety Hero. Another objective was to examine the engagement of the game by asking teens to rate their engagement with the game which will be used for future improvements of the game. Home

safety programs often focus on improving hazard identification and resolution (e.g., Senthilkumaran et al., 2019; Warda et al., 1999), and reaction times can be used as a proxy for measuring how effective learning was (e.g., quicker time might translate to better learning).

Methods

Participants

Participants were 10 parenting teens (*M* age = 17.68, *SD* = .87; all female) from an urban city in Central Pennsylvania. Most teens self-identified as white (81.1%), followed by White-Hispanic (6.3%), Black (6.3%), and mixed race (6.3%). Most teens reported their incomes in the poverty range ($24,000 to $26,000 / year). Approximately 80% of the teens identified as single; 80% of teens lived with their parents or a family member and 20% lived with a partner. All teens had one child (M_{age} = 1.06 years; SD_{age} = .80 years; range from 2 months to 2 years and five days old). They were enrolled in a local school district's parenting teens program. The teen parenting program includes teens between 14 and 19 years old, who are pregnant and/or parenting mothers and fathers. The program provides parenting education, includes regular high school curriculum, and is designed to help students who are parents or about to become parents complete their high school education and receive diplomas.

Procedure

The study was approved by the authors' Institutional Review Board and APA ethical standards were maintained throughout the duration of the study. A meeting was arranged with research personnel and program staff from the teen parenting program to discuss the purpose of the study and what teens would be expected to do. After agreeing to take part in the study, the program director of the teen parenting program obtained approval from the school district.

Program staff disseminated a consent document (if 18 years of age or older; $n = 6$) or a parental permission slip (if under the age of 18; $n = 4$) to teens who expressed interest in the study. Consent and parental permission slips were returned to school. Research personnel visited teens three times on separate days within two weeks at participants' high school. All visits were held in a private room. During the first visit, teens were informed of their rights as participants (e.g., voluntary nature of their participation, confidentiality of their data) and assent was collected from participants who were under the age of 18. If participants were 18 years of age or older, their desire to participate in the study was confirmed. Demographics information and the *Technology and Game Use* questionnaire were collected from all participants. During the second visit, teens played the game for the first time, with research personnel observing teens' game play. During the third visit, teens completed an engagement questionnaire. The first two visits occurred within the same week, while the third visit occurred seven days after the second visit. Between the second and third visit, teens played the game three additional times (for a total of four plays). We decided to space visits to reduce participant fatigue and to maintain the game design's emphasis on "spaced training" (Goverover et al., 2009; Vlach et al., 2008). All questionnaires were read to teens.

First visit. Teens were informed that their participation in the study was confidential. Research personnel gathered teens' assent for minors and confirmed consent for teens 18 or older. Teens completed demographics and the *Technology and Game Use* questionnaires.

Second visit. During this visit, teens played the simulation for the first time with research personnel observing game play. Before concluding the visit, teens were given information on how to access the simulation on a provided laptop and went through the steps to do so with the research personnel present (e.g., clicking the game's icon on the desktop). Based on the teen's

input, a tentative schedule for three more plays of the simulation was set up for the next seven day. Laptops were left in a locked cabinet and teens asked for the key from program staff.

Between the second and third visit. Between visit 2 and 3, teens independently played the game (all phases) again on three separate days within one week. If difficulties arose regarding the operation of the laptops, the teen parent program could contact the research personnel for assistance.

Third visit. In this visit, teens completed the *User Experience Survey*, were debriefed, and received an honorarium for completing the study. Each teen's game data was then downloaded from the laptop.

Materials

Demographics. Teens answered questions about their age, sex/gender, ethnicity, family income, the age of their child(ren), and who they live with.

Frequency of game play. Teens indicated how many hours per week they played games on a computer, smartphone, tablet, and gaming consoles (4 items total). The four items for playing games ($\alpha = .86$) were combined to form a final score on frequency of game play.

Engagement. The "Perceived Usability" subscale from *User Engagement Survey* was administered to teens upon completion of all four game plays to assess their engagement with the game (O'Brien & Toms, 2009). Answers ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The eight items for this subscale were all reversed scored. Example items included: "I felt discouraged while playing the game" and "Playing the game was mentally taxing". All items were combined to form a final score for "Perceived Engagement", with a Cronbach's alpha of .86.

Home Safety Hero

Design. The simulation was programmed with Unity 3D technology. Home Safety Hero targets the most common fatal and non-fatal injuries in young children (CDC, 2018): burns, falls, suffocation, drowning, cuts, firearms, and poison. During Home Safety Hero, rooms are explored in first-person by parents and they must identify risks, with and without distractions, and identify resolutions (see Figure 1 for game play visuals in the three phases). The simulation is divided into three phases, including Identification (30 levels), Resolution (12 levels), and Distraction (12 levels). Phases were organized based on recommendations for learning new skills through practice, which involves selecting appropriate actions (Identification and Distraction Phases; Diedrichsen & Kornysheva, 2015; Wolpert & Landy, 2012) and executing those actions (Resolution; Muller & Sternad, 2004; Reis et al., 2009; Shmuelof et al., 2012). At the beginning of the levels, parents read storylines concerning the placement of hazards in the house by different "monsters" (e.g., Burn Monster) who intend to harm hypothetical children. Description of the monsters are provided to inform parents about various examples of the different hazard types. Congratulations screens are included to increase parental engagement, along with hazard counter, and time bar. There are six virtual rooms, including kitchen scene, bedroom scenes, living room scene, hallway scene, and bathroom scene, distributed throughout the simulation (see Figure 2 for illustrations of rooms). Rooms were designed to include minimal furniture and items as to not clutter rooms and make identification easier, thereby promoting learning and reduce frustration. The visuals for the hazards are the same across all levels and phase and are randomized in different locations within the rooms. Hazards repeat across the levels, but never repeated within a level. To progress to the next level, parents must find all hazards or resolve hazards in the level before time runs out. Each level is two minutes long, and for each correct identification or resolution, 15 seconds are added to the timer. Parents cannot progress to the

next level until it is beaten. The simulation was designed to allow the player to stop levels and return where they left off, although teens played the game all in one session.

[INSERT FIGURE 1]

[INSERT FIGURE 2]

Identification phase. The Identification Phase involves parents locating hazards in the levels. When parents encounter a hazard, they click. There are three blocks of levels for finding five hazards, seven hazards, and 10 hazards. The decision to design levels by hazard type and then increase the number of hazards in the levels was intended to scaffold the learning process by slowly increasing the difficulty level and promoting mastery (Azar et al., 2018b). While teens played the game, their reaction time for finding each hazard per number of hazards in the level was recorded as well as the total number of times they clicked an object on the screen while also accounting for the total number of hazards in the level (called "clicks") and total number of fails (i.e., measured as running out of time in the level).

Resolution phase. The Resolution Phase involves parents locating hazards and selecting the best choice for resolving the hazard. When a hazard is selected, text appears, and a voiceover describes what the hazard is and acknowledges that the parent is concerned about the hazard. On the right-hand side of the text, there are four possible icons that involve different resolutions for dealing with the hazard, including doing nothing, putting the hazard out of reach, and locking it up. During game play, teens' reaction time to identify the correct hazard per number of hazards in the level was recorded, as well as the total number of times they clicked an object on the screen while also accounting for the total number of hazards in the level (i.e., called "clicks"), total number of incorrect solutions, and total number of fails.

Distraction phase. The Distraction Phase asks parents to locate hazards while also being distracted by sounds and/or information they must memorize. There are four blocks of levels, where the difficulty of the distraction and memorized information increases. For example, the levels range from asking parents to click on hazards while they hear a sound (e.g., premature baby crying) to clicking on hazards while a child moves around the room and trying to remember information from a phone call (e.g., location of a picnic). Teens' reaction time to find each hazard per number of hazards in the level was recorded, along with the total number of times they clicked an object on the screen while also accounting for the total number of hazards in the level (i.e., "clicks"), number of incorrect answers, and total number of fails.

Data Preparation and Analytic Plan

Descriptive statistics were also computed for number of fails and ratio of clicks per level. For Identification, the total number of hazards was 216 across all levels, 48 for Resolution Phase, and 120 for Distraction Phase. The ratio of clicks is then divided by the total number of hazards to provide a final number; numbers closer to 1 indicate that teens were clicking hazards at a similar rate in which the hazards occurred in the levels, providing insight into whether teens were randomly clicking. Furthermore, descriptive statistics were also performed for the incorrect solutions in the Resolution Phase and the incorrect answers in the Distraction Phase. The total number of possible correct solutions in the Resolution Phase was 48 and correct answers in the Distraction Phase was also 120. Percentages were computed by dividing the number of correct solutions or answers from the number of incorrect solutions or answers to form final scores for number of incorrect solutions and incorrect answers. Reaction times for game play were calculated by averaging the total time to identify or resolve hazards for all four plays of the Identification (4 total scores), Resolution (4 total scores), and Distraction (4 total scores) Phases

while accounting for the total number of hazards per level. To examine the ability of the simulation to promote learning through the identification of hazards and resolution of those hazards, three separate repeated-measures ANOVAs were conducted for each of the three phases of the simulation, while controlling for teens' frequency of game play. Tukey's post-hoc was performed to determine if reaction time means from each of the plays for the three phases were significantly different from each other. To examine teens' engagement with Home Safety Hero, the mean and standard deviation were calculated for "Perceived Engagement" subscale of the *User Engagement Survey*.

Results

Frequency of game play. On average, teens reported that they played games 5.03 hours (*SD* = 4.18 hours; range 0 to 12 hours) a week.

Game descriptive statistics. Across all phases and plays, there was only one fail in level five of the Identification Phase, where the participant ran out of time and was unable to find the fifth hazard in the level. For the Identification Phase, the average number of clicks for the first play was 1.89 (SD = .41), the second play was 1.74 (SD = .18), the third play was 1.71 (SD = .14), and the fourth play was 1.36 (SD = .15). For the Resolution Phase, the average number of clicks for the first play was 1.73 (SD = .36), the second play was 1.23 (SD = .10), the third play was 1.21 (SD = .10), and the fourth play was 1.19 (SD = .11). For the Distraction Phase, the average number of clicks for the first play was 1.43 (SD = .18), the second play was 1.11 (SD = .12), the third play was 1.09 (SD = .10), and the fourth play was 1.09 (SD = .12). Incorrect solutions for the Resolution Phase were 21.58% for the first play, 17.36% for the second play, 13.44% for the third play, and 12.5% the fourth play. Incorrect answers for the Distraction Phase

were 4.17% for the first play, 3.33% for the second play, 2.08% for the third play, and 0.83% the fourth play.

Game play reaction time. Significant main effects of reaction time were found for the Identification Phase, $F(3,6) = 41.74$, $p < .001$. Comparison of the multiple plays revealed that teens were significantly faster for in the fourth play ($M = 1.39$, $SD = .41$) when compared to all other times playing the game. Teens were faster with the third play ($M = 2.92$, $SD = .42$) than in the second play ($M = 3.38$, $SD = .79$) and the first play (M = 5.33, SD = .87), and they were also faster for the second play versus the first play. Similar patterns were found for the Resolution, $F(3,6) = 8.97$, $p = .012$, and Distraction Phases, $F(3,6) = 9.84$, $p = .010$, although the comparisons between the plays were slightly different. For the Resolution Phase, teens were significant faster for the second ($M = 13.19$, $SD = 1.62$), third ($M = 12.55$, $SD = 2.07$), and fourth ($M = 11.66$, $SD = 1.96$) plays when compared to the first play ($M = 15.55$, $SD = 1.81$). They were also faster for the fourth play versus the second play. For the Distraction Phase, teens were faster in the third ($M = 2.85$, $SD = .38$) and fourth ($M = 2.79$, $SD = .57$) plays when compared to the first ($M = 3.57$, $SD = .38$) and second ($M = 3.21$, $SD = .56$) plays.

[INSERT TABLE 1]

Game engagement. The engagement data indicates that teens found the game engaging ($M = 4.36$, $SD = .49$, range: 3.33 to 5.00).

Discussion

Home Safety Hero provides a novel approach to injury prevention programs through its integration of serious game principles to deliver home safety skills training via computer. The aim of the simulation is to decrease children's risk of unintentional injury by scaffolding parents' ability to respond to increased difficulty over time and to address potential problems in

attentional skills related to monitoring and scanning the environment for potential threats. The simulation slows down the learning process and allows for multiple trials. Multiple trials in injury prevention can refine skills and help these skills become more automatized and increase learning. Furthermore, multiple trials might be helpful for parents with slow processing speed (Azar et al., 2016). Elements of the simulation such as voice-overs and presentation of injury risks in multiple sensory modalities (e.g., visual illustrations of risk factors and voice-overs describing risk factors) compensate for potential literacy or learning problems. Furthermore, the simulation involves learning about multiple types of hazard categories simultaneously, something that is unique in comparison to other injury prevention programs utilizing technology that typically target just one risk (e.g., fire safety; for further review of the game's design: Anonymous, in preparation). Effective learning requires addressing individual differences in parents' cognitive abilities and rate of learning new skills, and thus individual tailoring via serious game simulation has promise (Azar et al., 2019).

Not only did the game measure reaction time, discussed next, it also assessed the amount of fails, ratio of clicks, and the percentage of incorrect solutions and incorrect answers. We found that only one participant failed a level. The participant failed level five, specifically, and this room involves a hallway that includes navigating around a small corner, while other rooms did not involve needing to look around any corners. It might have been likely that this participant had not realized that they were able to maneuver their cursor around the corner. The click ratio for all phases revealed values lower than two, suggesting that teens typically clicked on the screen at almost a one-on-one ratio. The ratio was similar to the exact number of hazards in the levels (e.g., clicking five times in a level with five hazards), indicating that it did not appear that teens were randomly clicking during gameplay.

The findings suggest improvement in speed of identification, with and without distraction, and for selecting appropriate resolution of risks across all four plays, as well as decreases in selecting incorrect solutions for the resolution phase and incorrect answers for the distraction phase. Such results indicate that parenting teens can spot the risks significantly quicker and more accurate, based on reaction times and percentage of incorrect solutions and answers, and that once risks are identified, they can act quicker when resolving risks. Finding improvements in identifying hazards and resolutions is aligned with other injury prevention programs that utilize web-based or computer software (Nansel et al., 2020; Gielen et al., 2007; van Beelen et al., 2014). Such findings expand the home safety injury prevention literature by "going beyond" pre-test/post-test designs to knowledge of safety.

Learning occurs when connections are made between new material and prior knowledge, which then become integrated into the learner's existing knowledge base as a script (i.e., sequence of actions/behaviors that relate to a particular situation; King, 2007). Thus, repeated trials and scaffolding of learning through increasing difficulty in Home Safety Hero creates a script for home safety information that can be activated in the real world and guide parents' behaviors. Furthermore, prior research (e.g., Azar et al., 2016a) indicates that parents often attribute home injuries to luck, suggesting that these parents might rely on biased scripts for dealing with home safety. Home Safety Hero could support the creation of new scripts that help parents recognize that they can control injuries in the home. When parents learn that they can control risks in the home, their parenting self-efficacy might increase.

Although this study is a preliminary investigation of Home Safety Hero, there are a few limitations and future direction that must be acknowledged. First, teens were all female and primarily white; thus, follow-up investigations are needed to also consider fathers and to include

adolescents from various racial backgrounds. It is common in research on fatherhood in adolescence to focus primarily on mothers (Hollman & Alderman, 2008). Second, the rooms were designed with minimal clutter to help facilitate learning; another version of Home Safety Hero should integrate a difficulty adjuster. Thus, as players become more adept at identifying and resolving hazards, the difficulty of the levels can be adjusted, and one type of adjustment might be to increase the clutter in rooms. The third consideration for future investigations it to modify the game to include more immersive virtual reality that might involve participants "picking" up hazards and performing corrective measures for these hazards. A fourth suggestion for a future research direction is to demonstrate the generalization of the game to the real-world. This might be possible by correlating game play reaction time to real-world behaviors, such as behaviors observed in a laboratory setting designed as a home with hazards present or observations of the actual home environment of parents. Future work might also use this game with mothers who have had problems with supervision to see if recidivism can be reduced (e.g., ones whose children have repeated visit to emergency rooms for injuries or ones who have neglected their children).

The engagement findings indicated that teens found the game engaging. Teens' ratings of Home Safety Hero were significantly better than found in prior studies using this instrument to assess engagement (O'Brien & Toms, 2009). The flexible nature of the simulation and gradual increase in difficulty allows parents to proceed at a comfortable pace which may prevent frustration and disengagement. Integration of labeled praise and rewards for success tied to the "Hero" narrative serve to provide consistent encouragement for parents as they progress through the simulation; praise and reward increase engagement and motivation (Cook et al., 2013;

Mozelius, 2014). The simulation instantiates the parent as a hero whose job it is to recognize hazards and stop injuries (Azar et al., 2018b).

Directly practicing parenting skills in a first-person virtually simulated environment closely resembles how parenting skills are learned in the real world but it does so in a way that promotes autonomy and mastery. The innovative design of this intervention or similarly designed interventions could have the potential to increase accessibility and extend the reach of universal injury prevention programs. In addition, Home Safety Hero was designed to address relational challenges that act as barriers to building trust with providers and leads to low satisfaction with services and reduced attrition. Despite increased difficulty and distraction of the levels, teens have the capacity to improve their ability to identify and resolve home safety hazards across multiple plays, turning them into "heroes" in their homes.

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Table 1

Average Reaction Time in Seconds Over Multiple Plays of the Identification, Resolution, and Distraction Phases

	First Play M (SD)	**Second Play M (SD)**	**Third Play M (SD)**	**Fourth Play M (SD)**	**F Test**	Differences Across Plays
Identification Phase	5.33 (.87)	3.38 (.79)	2.92 (.42)	1.39 (.41)	$F(3,6)=41.74$, $p < .001$	o Significantly faster on each subsequent play.
Resolution Phase	15.55 (1.81)	13.19 (1.62)	12.55 (2.07)	11.66 (1.96)	$F(3,6)=8.97$, $p = .012$	o Second, third, and fourth plays were faster than the first play. o Fourth play was faster than the second play.
Distraction Phase	3.57 (.38)	3.21 (.56)	2.85 (.38)	2.79 (.57)	$F(3,6)=9.84$, $p = .010$	o Third and fourth play were faster than the first and second plays. .

Note. Reaction times are reported in seconds and were averaged across all levels for each phase and combined to form final scores for each play across the three phases. Tukey's post-hoc tests were conducted to examine differences across play for each of the phases. The results of these tests are described in the far-right column.

Figure 1

Images of Game Play for Identification, Resolution, and Distraction Phases

Panel A. Image of Game Play from Identification Phase showing the yellow triangle hint for the burning cigarette hazard. The time-bar is on the right.

Panel B. Image of Game Play from Resolution Phase after selecting the detergent soap hazard. Icons for what should be done to resolve the hazard are listed on the right.

Panel C. Image of Game Play from Distraction Phase showing hazards surrounding an image of a child. Hazards surrounding the child must be selected first.

Figure 2

Images of the Six Room Designs in Home Safety Hero