Home healthcare hazard training through virtual simulation

Final Progress Report

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List of Terms and Abbreviations

FG – Focus group(s)
HHW - Home healthcare workers
IV(s) – Interview(s)
Occupational therapy – (OT)
Physical therapy - PT
VSTS - Virtual Simulation Training System
UUD – Usability, usefulness, and desirability

Abstract

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The growing number of Home Health Aides and Personal Care Aides is expected to exceed 4.1 million by 2026. Increases in home healthcare services and workers are attributed to the aging population, increased outpatient care, decreased hospital lengths of stay, cost savings, and patient preferences. Home environments are more challenging and variable than other healthcare work environments. In 2015 the Bureau of Labor Statistics reported incidence rates for home health aides and personal care assistants, at 117.9 and 132, respectively, exceeded the average rate of 93.9 cases per 10,000 workers for private industry as a whole. 60% of home health aide injuries have been reported to occur inside patient homes and are associated with patient handling tasks, medical devices, equipment, and other environmental factors. Given the increase in healthcare provided in homes, and hazards faced by home healthcare workers (HHWs), it is critical that these workers receive appropriate occupational safety and health training to be able to identify, assess, and respond to hazards in client's homes.

This project addressed this training need by developing and assessing the efficacy of an appealing, interactive, widely-distributable, virtual simulation training system (VSTS). Using a rigorous, interdisciplinary, participatory, and iterative design process and mixed methods research approach, a VSTS was created that includes a tutorial, orientation, three training modules (Electrical/Fire/Burn, Slip/Trip/Lift, and Environmental hazards) and Assessment module that trains and assesses ability of HHWs to identify and respond to occupational health and safety hazards in client homes.

Key findings: Phase 1: Interviews and focus groups with 68 experienced HHWs confirmed that they encounter a wide range of hazards in client homes, including fall/trip/slip hazards, biohazards, air quality issues, allergens, pests/rodents, and burning candles; each was mentioned by >50% of participants. Data analysis also revealed that >50% of hazard management decisions discussed by participants were less than optimal, confirming the need for training to go beyond hazard identification to include response training. Phase 2: Results from usability assessments of the VSTS were used, in an action research approach, to address usability issues as they were identified. Phase 3: Training program efficacy was demonstrated through an experiment, wherein 54 HHW and 39 healthcare profession students (occupational or physical therapy, or nursing) were randomly allocated to experimental training (VSTS) or standard training (training information printed on paper with illustrations). Performance results were similar between the groups (e.g. similar numbers of hazards correctly identified). The experimental group also provided usability assessments that showed large majorities of users found the VSTS to be easy to use and anticipated that their co-workers would quickly learn how to use it. Further analysis revealed that VSTS usability was not affected by computer use history or computer gaming experience. Analysis also revealed opportunities for improving the VSTS (e.g., providing alternative channels for conveying content, given the significant amount of reading currently required when using the VSTS). The VSTS is accessible to anyone who would like to use it, and plans are being developed for broader scale effectiveness testing.

Section 1 of the Final Progress Report

Significant or Key Findings

Specific Aim 1. Use an interdisciplinary, user-centered, participatory, iterative process to develop and assess an interactive virtual simulation training system (VSTS) to train home healthcare professionals to recognize, assess, and respond to hazardous conditions in patients' homes.

Significant findings:

- Surveys, interviews and focus group discussions informed and confirmed the types of hazards that home healthcare workers (HHWs) encounter in client's homes. Trip/slip/lift hazards were the most common hazards encountered by home healthcare workers throughout the home but, with the exception of throw rugs, hazards varied from room to room. Biohazards were most common in the kitchen and bathroom, while electrical and fire hazards were most common in the kitchen.
- Participants provided their ideas for the design of the training program. They indicated that the VSTS should take no longer than one hour, and each training module should take about 10-15 min to complete.
- Feedback from the training to the home healthcare worker should be provided room-by-room, humor can be included in the feedback mechanism, and links to resources/guidelines, handouts, and/or a smartphone app that could be accessed in a home healthcare situation would be helpful.
- Participants also recommended that a video tour of the home occur prior to beginning the VSTS, and that the training should be case-based, allow multiple sessions, and include audio.
- A majority of hazard management decisions (66.5%) that were described by study participants were classified as less than optimal, confirming the need for the training to include hazard identification and hazard management information.

Specific Aim 2. Assess the usefulness, usability, and desirability of the virtual simulation training system across disciplines of home healthcare professionals and modify the system accordingly.

Significant findings:

These findings were from the assessment that was conducted during development of the VSTS.

- Participants found the three training simulations easy to use, not too complicated, and believed their co-workers would learn to use the training simulation fairly easily.
- Participants indicated that the training simulations provide useful information that could help keep them safe.
- Participants found the "what to do" hazards management information useful, and that the program taught them something new.
- The program was not felt to be boring and participants indicated they would like to have it in their work setting.

These findings were from the assessment was conducted during the efficacy experiment.

- Difference between participants based on weekly computer use: 38% of those who reported low computer use found it easy to move through the virtual home compared to 67% of those who reported moderate-high computer use, and 85% of those who identified as college students.
- Among participants who reported limited experience with computer gaming, about 53% reported difficulty moving through the house as compared to 16% with moderate or a lot of experience.

Specific Aim 3. Evaluate the efficacy of the virtual simulation training system in preparing home healthcare professionals to recognize, assess, and respond to hazards in the home health environment using appropriate risk perception and decision-making processes.

Significant findings:

- VSTS users were able to correctly identify and classify hazards as such.
- No significant differences in identification of hazards in the Assessment module based on type of job (home healthcare aide/homemaker, other home healthcare workers, students), age group (≤29

years, 30+ years), years in home healthcare (≤5 years, 6+ years), computer gaming experience (yes/no), or comfort with computer technology.
- Students in healthcare profession programs responded correctly significantly more often to the 'What to do' items compared to home healthcare aides.

Translation of Findings

The study findings from Aims 1 and 2 have been translated into the VSTS. The VSTS is available for download and use (https://homehealthcaresafety.osu.edu/). A number of peer-reviewed manuscripts have been published, with at least three more planned or in process. Information about the study has also been presented at a number of conferences in the forms of talks and posters.

Research Outcomes/Impact

The outcomes from this study are classified as "potential outcomes, i.e., findings, results, or recommendations that could impact workplace risk if used". This research developed a virtual simulation training system for providing an informative, engaging, interactive training experience for home healthcare workers, which is particularly aimed at informing HHW about hazards in client home that pose a safety risk to the HHW. An important aspect of the training content is that it provides "what to do" hazard management information, as well as hazard awareness information, to users. The outcomes are classified as "potential outcomes" because the study, as designed, progressed from development to efficacy testing, but we have not yet conducted effectiveness testing, nor has there been any planned distribution of the VSTS, although it is available for download from our website (URL provided above). This study has demonstrated the benefit of participatory research methods in developing a training system that users find useful and usable. The study has also demonstrated the efficacy of the VSTS for training the target audience, home healthcare workers, a vulnerable population, given the vast majority of these workers are female and are working alone in work environments that are not under an employer's control.

Section 2 of the Final Progress Report

Background

The rapid increase in home healthcare services and home healthcare workers (HHWs) is due to an aging population, increased outpatient care, reduced hospital lengths of stay, cost savings, and patient preferences (Agbonifo, Hittle, Suarez, & Davis, 2017; Hogan, Decmber, 2015). Client homes are more challenging and variable than other healthcare environments (Darragh et al., 2016). The Bureau of Labor Statistics documents 27,000+ HHW injuries associated with providing home health care services (U.S. Bureau of Labor Statistics, 2015b); 11,000+ resulted in lost work days (U.S. Bureau of Labor Statistics, 2015a). Approximately half of the injuries were sprain, strains, or tears. Injury sources included floors, walkways, or ground surfaces (24%) and worker posture (12%) (Agbonifo et al., 2017; Cloutier et al., 2008; Schoenfisch, Lipscomb, & Phillips, 2017; U.S. Bureau of Labor Statistics, 2015a). HHWs also are exposed to hazards such as bodily fluids, tobacco smoke, home oxygen use, aggressive pets, pests, home temperature/humidity, cleaning chemicals, and sharps that cause injury and illness (Agbonifo et al., 2017; R. R. Gershon et al., 2008; R. R. M. Gershon, A. N. Canton, et al., 2008; Gershon et al., 2009; Gershon, Pogorzelska, Qureshi, & Sherman, 2008; Hittle, Agbonifo, Suarez, Davis, & Ballard, 2016; National Institute for Occupational Safety and Health, 2010; Polivka et al., 2015). Current training approaches for assessing and responding to home hazards are limited in scope and evidence for efficacy (Capewell, Brown, & Rockefeller, 2011; Hamadi, Probst, Khan, Bellinger, & Porter, 2016; Hittle et al., 2016; Larsson, Karlqvist, Westerberg, & Gard, 2013; McCaughey et al., 2012; Palesy, 2016). Empirically validated training approaches are needed to address the health and safety hazards in home healthcare to improve HHW health and safety outcomes.

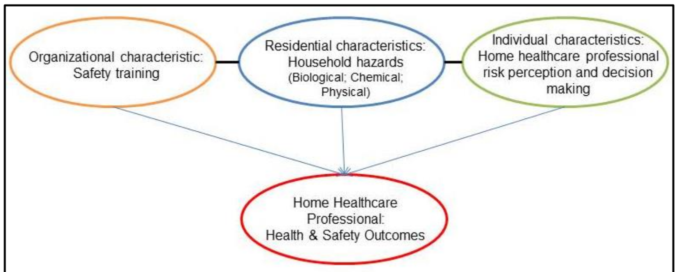

Figure 1. Health and safety in the home healthcare setting framework (Gershon, et al., 2008)

The virtual simulation training system (VSTS) is grounded in the Gershon et al. framework for Health and Safety in the Home Healthcare setting (Figure 1) (R. R. M. Gershon, A. N. Canton, et al., 2008). The primary emphasis of the VSTS is to influence individual risk perception and decision-making behaviors by providing users with hazard rationale and response strategies. Specifically, the VSTS is designed to: (1) increase HHW awareness of residential hazards, (2) achieve accurate calibration of risk perceptions based on objective risk characteristics (harm likelihood, severity, frequency of hazards), and (3) provide specific options for responding to hazards. To facilitate broad distribution, the VSTS was built on an internet-downloadable gaming platform.

Individual Characteristics: Risk perception and decision-making. Gershon et al. (2008) asserted that individual characteristics such as risk perception and decision-making impact health and safety outcomes in HHWs. Strategies to improve risk perception and decision making within the VSTS (Griffin, Dunwoody, & Neuwirth, 1999) include presentation of objective information about risk characteristics: (1) harm likelihood (absolute/relative risks), (2) potential severity of harm (e.g., extent of harm if oxygen-induced fire/explosion occurred), and (3) frequency of hazards in homes (e.g., throw rugs), as well as information about specific hazard management approaches (“what to do”). HHW navigation in the VSTS to identify hazards and learn about hazard management response options reinforces both improved risk perceptions and effective hazard management responses by embedding learning in a realistic home environment.

Residential Characteristics: Household hazards. Hazards included in the VSTS were derived from HHW focus groups during the design phase of the VSTS and verified through evidence review (Czuba, Sommerich, & Lavender, 2012; Polivka et al., 2015). They are embedded in contextually appropriate locations in the VSTS home environment. The VSTS also contains information about conducting a home safety walkthrough to note residential features and potential hazards (Wills et al., 2016).

Organizational characteristics: Safety training. The VSTS contains multiple features designed to facilitate use by organizations. For example, the laptop/desktop version of the VSTS can be downloaded without cost, training modules can be entered and exited multiple times, and home healthcare agencies can require a certain score be obtained in the Assessment module (e.g., 80%) to demonstrate competence.

Translation of Training in Interactive Virtual Environments. Several meta-analyses document the efficacy of simulation for training and assessment (Bossard, Kermarrec, Buche, & Tisseau, 2008). Interactive simulations or games have been shown to achieve superior learning compared to traditional teaching methods, across gender, learner control, type of activity, age, and realism (Vogel et al., 2006).

Specific Aim 1

Use an interdisciplinary, user-centered, participatory, iterative process to develop and assess an interactive VSTS to train home healthcare professionals to recognize, assess, and respond to hazardous conditions in patients' homes.

Research questions:

1. What hazards do home healthcare workers from different disciplines experience when providing care to patients in their homes?
2. What are the training needs, the training content, and the perceived constraints on the training of home healthcare professionals regarding home care safety hazards?

Methods - Aim 1

The design process for creating this innovative VSTS built on the experience and expertise of several stakeholder groups to create the innovative VSTS. Individuals representing these different stakeholder groups were recruited for focus groups (FG) and interviews (IV). These sessions were aimed at identifying training needs, training content, and perceived constraints on the training process. The data were used to design the initial VSTS which, once programmed was evaluated by recruiting HHWs to address usability and desirability issues through an iterative process evaluated in Aim 2.

To address Aim 1, we used the experiences and expertise of multiple stakeholder groups (home healthcare nurses, aides, therapists, managers, educators, and health and safety experts), combined with a review of the scientific literature, to create the VSTS. Individuals representing these different stakeholder groups were recruited for FG and IVs. These sessions identified hazards in the home healthcare environment, training needs, training content, and perceived constraints on the training process (Table 1).

Table 1. Focus Group/Interview Guide used to identify hazards home healthcare professionals experience with providing care to patients, identify their training needs and explore desired content in a virtual simulation training system.

1. Tell me/us about any environmental health or safety concerns you (or your employees) have had while working in home health care.

a) Question 16 on the questionnaire you completed before you came asks about any injuries you (or your employees) have had in the home healthcare setting within the past 3 years. If you indicated you had an injury – what hazard caused that injury?

b) If you were orienting a new employee to home healthcare – what environmental health and safety hazards would you want to tell them about?

Activity: One method of training is by virtual simulation. By virtual simulation we mean computer-based training that is interactive, allows you to actually see the home healthcare environment, and interact with some of the health and safety issues you may run into. We are going to be developing this type of virtual simulation and we would appreciate your help.

Ask each participant to draw in the environmental health and safety concerns that immediately come to mind for that room. Take a few minutes – then have participants pass their sheet to the person next to them, the next person can add to the drawing or draw a new one (can add a smiley face if they think it was great). Allow discussion and exchange of ideas. Individual interviews – this activity will be completed on their own >> Once everyone has had a chance to input environmental health and safety concerns on each drawing – Post/project the drawings and open discussion about the drawings.

2. *Focus Group: Let's talk about these drawings – what's missing, what do you agree with/disagree with?

Now you get to vote for the most important environmental health and safety concerns in each room. We will give you 15 dots each - 3 dots per room. Please go and place 3 dots on the most important health and safety concern in the Living Room, 3 dots in the Bedroom, 3 dots in the Bathroom, 3 dots in the Kitchen, and 3 dots in the hallway. <<Pass out dots>>

a) Why did you place your dots on these three areas?

b) Are these the areas you think should be included in a computer-based training?

2. *Individuals interviews: Of the hazards you mentioned, which ones do you feel are the most important hazards you or your employees have encountered in the home healthcare setting?

3. *Focus Group: Describe any training you've had with regards to environmental health and safety issues in the home healthcare setting.

a) If you've had different types of training, which did you find more useful?

b) How effective was the training?

c) Did you have any training that addressed any of the hazards on our list or in the drawings?

3. *Individual Interview: Describe any training your employees are provided related to environmental health and safety issues in the home healthcare setting.

a) If you've used different types of training, which did you find more useful?
b) How effective was the training?
c) Do your employees have any training that addressed any of the hazards on our list or that you have mentioned?

<<*Probes*: classroom, video, books, internet, on-the-job, lectures>>

4. *Focus Groups: If you were completing computer-based training about health and safety concerns in patients' homes:

a) How and when would you like to receive feedback on how you did in the computer-based training?
b) How long do you think the training session should last?
c) Would you like to the training all at once, in multiple sessions, or by topic area (e.g., mold, ergonomic hazards)?

4. *Individual Interviews: If you were helping design a training program for new home healthcare workers about environmental health and safety issues they may find in patients' homes, what are the most important issues that should be included?

<<*Probes:* Look at items on list if needed>>

5. *Individual Interviews: If your employees were completing computer-based training about environmental health and safety concerns in patients' homes

a) How and when do you think they would you like to receive feedback on how they did in the computer-based training?
b) How long do you think the training session should last?
c) Would you like your employees to do the training all at once or in multiple sessions?

5. Is there anything that we didn't talk about regarding environmental health and safety concerns in home healthcare, training needs, or information in a computer-based training system?

FG and IV participants completed drawings illustrating actual hazards encountered in the homes in which they have worked. Each participant was asked to draw the environmental and safety hazards that came to mind for either the bedroom, bathroom, kitchen, hallway, or living room. In FG settings, once that room was completed it was passed to the next FG participant who added their ideas to the drawing. Each participant had an opportunity to add to each drawing as well as to provide written comments about the hazards depicted. Each participant placed adhesive dot stickers on the three hazards they perceived as most important in each room. The drawings were then discussed and prioritized hazards confirmed. Interview participants had the opportunity to describe room-based hazards in several ways. Some dictated instructions to the facilitator who furnished rooms, labeled hazards, and added "stickers" using a shared computer desktop. Others completed drawings by themselves during the interview or verbally discussed hazards they had encountered in specific rooms in client homes.

Digital recordings of all FGs and IVs were transcribed and the transcriptions were validated for transcription accuracy. Once validated, transcripts were uploaded into Dedoose qualitative software for analysis. Each transcript was independently coded by a minimum of two members of the research team for hazards and for training needs. Hazards in the home were coded as overall hazards, and also were coded and categorized by room including the kitchen, bedroom, bathroom, hallway, and living room (rooms that are included in the virtual simulation). Independently coded transcripts were compared for inter-rater reliability and any discrepancies were resolved through discussion.

Results - Aim 1

We completed eight FGs (with 2-5 participants per group) and 37 IVs. A total of 68 home healthcare workers participated in Aim 1; saturation was reached. Most participants were female (95%), registered nurses (31%), aides/homemakers (21%), administrators/educators (19%), or physical/occupational therapists (19%). While 42% were from Ohio, participants were also from Kentucky, Minnesota, Colorado, Illinois, Florida, Indiana, Iowa, North Carolina, South Carolina, Washington, and Wyoming. Most provided care in suburban areas (68%), with 37% working in urban locations, and 17.5% in rural areas. FG and IV participants completed the Modified-Home Healthcare Worker Questionnaire (M-HHCW) which includes information on home healthcare tasks, injuries/exposures they experienced in home settings, training received in current job, exposures to

Table 2. Hazards encountered in home healthcare as reported in the M-HHW questionnaire

Exposure type	n (%)
Fall/trip/slip hazards	56 (88.9)
Biohazards	55 (87.3)
Air quality	55 (87.3)
Allergens	48 (76.2)
Pests/rodents	47 (74.6)
Burning candles	36 (62.1)
Poor lighting	19 (32.8)
Chemicals	18 (31.0)
Illicit drugs	14 (24.1)

hazards in patients' homes, health history, and computer literacy. Table 2 indicates the most common hazards reported by participants on the M-HHCW.

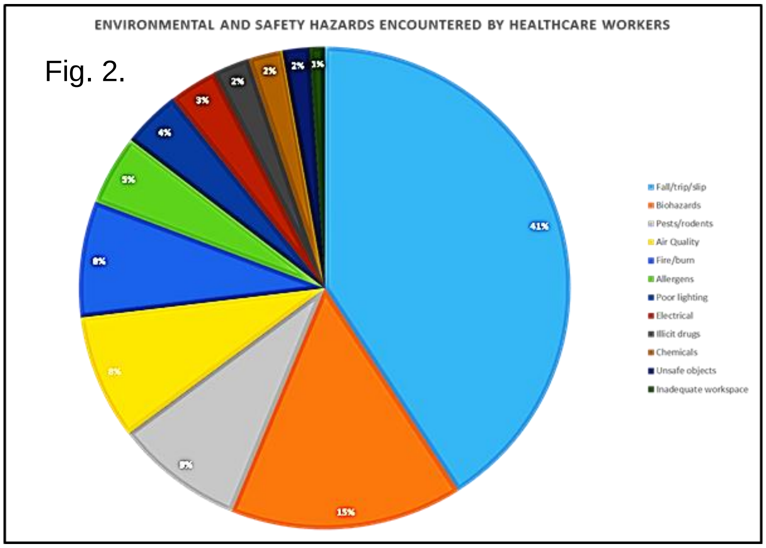

Fig. 2.

Analysis of the digital recordings revealed that trip/slip/lift hazards were the most common hazards encounter by HHW throughout the home but, with the exception of throw rugs, varied from room to room (Figure 2). Biohazards were most common in the kitchen and bathroom, while electrical and fire hazards were most common in the kitchen (Figure 3).

Participants indicated that the VSTS should take no longer than one hour, and each training scenario (electric/fire/burn, environmental, trip/slip/lift) should take about 10-15 min to complete. Additionally, feedback to the HHWs should be provided room-by-room, humor can be included in the feedback mechanism, and links to resources/guidelines, handouts, and/or a smartphone app that could be accessed in a home healthcare situation would be helpful. Participants also recommended that a video tour of the home occur prior to beginning the VSTS, and that the training should be case-based, allow multiple sessions, and include audio. These suggestions were addressed in the development of the VSTS (video tour, case-based modules) and in subsequent grant applications (smartphone app development) (Polivka et al., 2015).

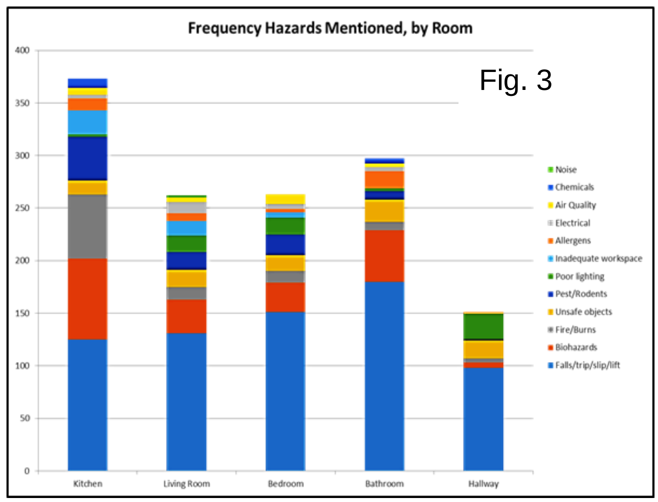

Fig. 3

As part of Aim 1, to inform the design of the VSTS to prepare HHWs to respond to hazards using appropriate decision-making processes, transcripts were also coded for types of hazard management decision-making dilemmas and level of decision quality.

A decision-making dilemma was defined as a situation in a client home for which the HHW needed to assess the risks for her/his own health and to evaluate tradeoffs in deciding what should be done to manage the hazard. Often-described dilemmas included exposure to client tobacco smoke and smoking with oxygen, non-removal of fall hazards (e.g., snow, ice, throw rugs, & clutter), other musculoskeletal risks, and environmental hazards (e.g., aggressive unconfined pets, inadequate protection from biohazards). With regards to categorization of quality of decision-making, "Optimal" decision-making about hazard management was defined as effective mitigation of the health hazard without significant disadvantages for the HHW or client. "Mixed" decision-making may or may not have been effective in hazard mitigation, and/or had significant tradeoffs for the HHW and/or client. "Suboptimal" decision-making was ineffective or otherwise inappropriate in health hazard mitigation and/or involved setting aside the health needs of the HHW and/or client.

Table 3. Levels of decision quality by types of dilemmas*

Hazard Dilemmas and Levels of Decision Quality	n (%)
Electrical and Fire Hazards	40 (10.2%)
Optimal	11 (27.5%)
Mixed	16 (40.0%)
Suboptimal	13 (32.5%)
Fall, Trip, Slip Hazards	162 (41.1%)
Optimal	51 (31.5%)
Mixed	49 (30.2%)
Suboptimal	62 (38.3%)
Environmental Exposures	192 (48.7%)
Optimal	70 (36.5%)
Mixed	65 (33.8%)
Suboptimal	57 (29.7%)

*Based on 394 specific types of hazards within 353 discrete decision-making dilemmas.

A majority of hazard management decisions (66.5%) were classified as less than optimal ("Mixed" or "Suboptimal"; Table 3). Mixed and suboptimal decisions included HHWs: (a) setting aside their own health and safety needs to accomplish healthcare tasks; (b) deferring action on addressing hazards; and, (c) sub-optimally addressing hazards by "making do" (e.g., "there's nothing that can be done"). These results document the need to improve HHW decision-making about home health hazards management as means of favorably impacting HHW health, safety, and costs due to preventable injuries and illness. The VSTS addresses key sources of less-than-optimal approaches to often-described hazards management dilemmas to improve HHW decision-making processes (Wills et al., 2016).

Building the Virtual Simulation Training System (VSTS)
The integration of information of typical dwellings and hazards experienced by both experts and FG participants was used to derive our design of the VSTS. This information guided the translation into a three-dimensional (3D) computer model of an archetype dwelling. The design not only provided a representation of the dwelling, it also provided a design that allowed for the types of functionality to present a diverse depiction of common home hazards through virtual technologies.

The original design was to distribute one application to multiple platforms. This means that the distributed versions would not have the best capabilities, interactions, and graphics. Because the requirement included mass distribution, many compromises were necessary to support older hardware platforms. The project originally utilized Unity's web browser plugin, which provided a standardized experience for anyone able to install the plugin. The heavy-lifting to support the hardware was done by the Unity plugin, allowing the development to work on the content. However, these plugin-type interfaces into web browsers have huge security risks. All of the leading internet browser developers have been removing support due to how easy it is to compromise the security of a system. An open standard (WebGL) is the new method for having an interactive 3D graphics experience in a web browser, but unfortunately the standard and specific browser implementations are very nascent. We have experienced a number of performance issues using WebGL.

The development group focused on bug fixes and minor improvements to the desktop/laptop version of the VSTS built using the Unity™ gaming engine. Because of the previously targeted desktop/laptop configuration, data complexity and textures were down-sampled so that the resulting game would work well with older computer hardware. We updated this complexity and textures to improve the visual refinement. The goal was to ensure the robust use of the desktop/laptop system's in obtaining data. This goal has been accomplished.

Through a combination of computer modeling (Blender™, Maya™) and gaming (Unity™) software, we have designed and developed a flexible and interactive virtual environment for the purpose of home healthcare safety training and assessment. Because the main goal is to support training and assessment, this approach would be classified as a "serious game".

Structural development. The structural components of the virtual environment includes a simple 2-story dwelling with a partial basement. This virtual dwelling serves as a paragon for many typical living environments encountered by home healthcare professionals. Guided by information provided by our FGs and IVs, we subsequently modeled the various assets, i.e., furniture, appliances, and sundry personal items typically found in a typical dwelling of a home healthcare patient.

Functional development. Once the components of the virtual environment were completed, we focused on how participants would intuitively interact with the environment. This interaction includes three specific training modules based on our FG/IV data collected. The three training modules focus on three types of hazards encountered by the home healthcare professional: (1) fire/electrical/burn hazards, (2) environmental hazards, and (3) slip/lift/trip hazards. An Assessment module incorporating all three types of hazards was also created to assess trainees grasp of hazard identification and response.

During interaction and training with a specific module, the participant selects any of the myriad objects, or assets, found in the virtual environment, that to their knowledge may constitute a hazard. Selection of assets is accomplished by pointing to an asset in the scene. Upon selection, a dialogue box appears on the screen. Further interaction with the game is suspended to allow for interaction with the dialogue box. Users also have a flashlight and magnifier to examine conditions and hazards more closely. Assets such as fire alarms or water faucets can be tested as working/not working.

If their selection is not a hazard, a brief justification is provided, and they are returned to the game. If the selection is a hazard, again a brief justification is provided. Subsequently, the user is provided additional information with regard to the selected hazard concerning why it's a hazard and what they could do to address the hazard. Additional information may include text, and/or image(s). All interactions and selections are tracked and stored in a single session file for each training module and for the assessment module.

In addition to creating specific assets (room features and safety hazards) and integrating them into the functioning virtual environment, the group has established "hooks" into user activities to provide quantification of performance as required in the Assessment module. These quantifications include tracking of user location within the virtual environment, i.e., kitchen, bathroom, the number of possible hazards encountered in each area, the number of correct and incorrect selections, and the time to task, i.e., the time to complete a module.

We have seen a wide variety in the participants' command of the user interface. Some participants, who are comfortable with computer (gaming) interfaces, appear to have limited problems with the user interface, and achieve a decent level of proficiency fairly quickly. However, some participants, who exhibit limited computer literacy, find the keyboard interface somewhat problematic. Navigation using the gaming paradigm of "W", "A", "S", and "D" (WASD) keys (or the arrow keys) and a 2D mouse can be sub-optimal for 3D spatial navigation. Difficulty in navigation may also possibly arise from either low computer literacy and/or poor spatial literacy.

Interactive Virtual environment. Because the task of learning about home hazards takes place in a three-dimensional world, two-dimensional interfaces can be limiting for training people about hazards. We have found that two-dimensional interfaces, coupled with keyboard navigation can be challenging to use, especially for those with limited computer literacy, and adversely impact the usability and desirability of the system. Subsequently, to address the need for intuitive navigation, an interactive virtual environment has been developed in the Interface Lab. The interactive virtual environment allows the user to walk around freely via typical ambulation. The position and location of the user is computed using a desktop workstation connected to the tracking system. A backpack computer (MSI VR1™) provides all graphic rendering required for the simulation. This backpack configuration provides "tether-less" movement within a 20' x 20' space (Figure 4). An Oculus rift™ head mounted display provides the user a visual display of the virtual environment. The Oculus provides a stereo visual display and supports 3D sound environment. An OptiTrack™ optical tracking system tracks the position and directions of the user with submillimeter accuracy. Manual controllers are integrated for selecting objects and for user response to the system. Thus the interactive virtual environment provides a more natural interface for the user, and allows for studies to be more ecologically valid. By supporting normal ambulatory motion and replacing the mouse and keyboard with line of sight and hand-held point and click 3D technologies, the training experience becomes more enjoyable, intuitive, and feasible for HHWs who many have limited computer use experience.

Figure 4. Example of a user engaged with the interactive virtual environment.

An additional focus in the development process included identifying a solution to improve the visual fidelity and to enhance the natural interactivity of the system. Previous development has taken place using Unity software. We have now been exploring the recreation using Unreal Engine 4™ (UE4), We have found UE4 to have superior lighting capabilities. UE4 provides a physically based rendering system that presents a high level of visual fidelity. In addition, UE4 has considerable capabilities to create natural phenomenon such as steam, fog, fire, and smoke (Figure 5). Finally, UE4 allows for many natural interactions such as dropped objects and breakage. These soft and rigid body dynamics are integrated into the system for physical interactions. The advantage this design is improved realism, a more real representation of reality, one that should improve engagement.

Figure 5. Figure 5. LEFT: Living room fire using Unity targeted for web-based delivery RIGHT: Living room fire using UE4 targeted for use in iVe system.

Specific Aim 2

Assess the usefulness, usability, and desirability (UUD) of the VSTS across disciplines of home healthcare professionals and modify the system accordingly.

Research Questions:

1. What is the perceived UUD of the VSTS by home healthcare professionals?

a. How does the UUD of the VSTS differ by home healthcare discipline, years of experience, and exposure to hazards in the home healthcare environment?

Table 4. Aim 2 Participant Characteristics	
State	
Alaska	1 (4.2%)
Kentucky	9 (37.5%)
Indiana	1 (4.2%)
Ohio	10 (41.7%)
North Carolina	1 (4.2%)
Wisconsin	2 (8.3%
Job type	
RN/ LPN	8 (33.3%)
Aide/Homemaker	6 (25.0%)
Manager	3 (12.5%)
Other	67 (29.2%)
Female	24 (100%)
Race	
African-American	5 (20.8%)
Native American	1 (4.2)
White	18 (75.0%)

Methods - Aim 2

In Aim 2 a multi-method study design was used to evaluate the UUD ability of the VSTS for home healthcare workers. Qualitative FG/IV data were collected along with quantitative, questionnaire-based data. Aim 2 continued the iterative development of the VSTS and the formative evaluation of the VSTS by the research team. The VSTS includes three training modules: Slip/trip/lift hazards; Fire/electric/burn hazards, Slip/lift/trip hazards, and Environmental hazards. In addition, the VSTS contains one Assessment module that contains hazards from each of the three training modules. Each training simulation addresses a different client scenario. The training simulation scenarios and hazard list by rooms are attached in the Appendices. An Overview and Initial Walk-Through voice-over videos was created to orient trainees to the simulation and to the process of conducting a home safety assessment.

Results - Aim 2

Twenty-four home healthcare workers participated in Aim 2 UUD assessment (goal was to have 21 participants). Participant demographics are noted in Table 4. Participants were from six states, reflected more than six types of home healthcare workers, a mix of racial groups, and workers from both for profit (61%) and not-for-profit agencies (39%). After reviewing the training simulations, participants completed a survey assessing the UUD of the VSTS. Results are presented in Table 5. Overall, participants found the three training modules easy to use, not too complicated, and believed their co-workers would learn to use the training simulation fairly easily. All participants indicated that the training simulations provided useful information that could help keep them safe. The program was not felt to be boring and participants indicated they would like to have it in their work setting. When asked to rate the usefulness of the training program on a scale of 1 (Not useful) to 7 (Very useful), the average rating was 6.4 (SD=0.7). There were no statistically significant differences in UUD assessment by home healthcare discipline or years of experience. We did not collect exposures to hazards in the home healthcare environment for this UUD assessment.

Table 5. Usability, Usefulness, and Desirability Assessment of the Three Training Simulations (n=24)			
Usability	Strongly Disagree/ Disagree	Neutral	Agree/ Strongly Agree
1. The training program was easy to use.	4.5%	4.5%	90.9%
2. The training program was too complicated.	81.8%	13.6%	4.5%
3. This training program took too long to finish.	68.2%	13.6%	18.2%
4. It was easy to move through the house.	9.1%	18.2%	72.7%
5. The keyboard controls were easy to use.	9.1%	22.7%	68.2%
6. It was hard to see the hazards.	68.2%	22.7%	9.1%
7. It was easy to click-on the hazards.	4.5%	13.6%	81.8%
8. The information boxes were easy to click through.	0	0	100%
9. I think my co-workers would need help to use this training program.	36.4%	31.8%	31.8%
10. I think my co-workers would learn to use this training program very quickly.	9.1%	22.7%	68.2%
Usefulness			
1. This training program will help me identify hazards in my clients' homes.	0	0	100%
2. The "what to do" information provided by the program is useful to me.	0	4.5%	95.5%
4. The program taught me something new about hazards.	9.5%	19.0%	71.4%
6. The information in the training is too simple.	77.3%	22.7%	0
7. The training program shows me too many types of hazards that are out of my control.	95.2%	4.8%	0
8. The information from this training program can help keep home health care workers safe.	0	0	100%
Desirability			
1. I liked this training program.	0	9.1%	90.9%
2. This training program was boring.	90.9%	9.1%	0
3. I wish we had this kind of training program in my agency	0	4.5%	95.5%
4. My co-workers would like to use this training program	0	0	100%

Interview data from participants was very positive. Participants provided numerous suggestions, comments, and concerns regarding all aspects of the VSTS. These suggestions, comments, and concerns were thoroughly discussed by the research team after each UUD assessment and strategies to address the suggestions and concerns were developed and implemented. For example, the initial home screen for the VSTS did not clearly indicate where the trainee should begin. The home screen was modified to clearly indicate the order by which the trainee should proceed through the VSTS (See Figure 6). This modification was well received by participants.

Another example of the changes incorporated after UUD feedback is the development and implementation of the Overview and Walk-Through segments. These segments were added when UUD participants indicated they needed guidance from research team members to find the rooms in the virtual home. Scripts were developed, and a voice-over presentation was recorded for the Overview and for the Walk-Through. The Overview introduces the trainee to a Job Safety Analysis including an initial walk-through and a safety check of each room in the client's home. This is followed by an overview of the various components of the VSTS. The Walk-Through of the VSTS visually introduces the trainee to the layout of the home (various rooms and their locations) and how to manipulate through the VSTS to find the rooms, thus familiarizing trainees with all the structural aspects of the virtual home. After the Overview and Walk-Through were included in the VSTS participants were more easily able to negotiate moving through the VSTS and find all the virtual rooms.

The research team reviewed all aspects of the VSTS to identify directions/areas that needed further explanation so that HHWs unfamiliar with computers and/or gaming language would be able to negotiate the

VSTS. Feedback after these changes were positive and UUD participants were able to manipulate through the VSTS more quickly and with greater ease.

Figure 6. Initial (left) and revised (right) home (starting) screens for the VSTS; revisions were directly due to usability feedback.

Specific Aim 3

Evaluate the efficacy of the VSTS in preparing home healthcare professionals to recognize, assess, and respond to hazards in the home health environment using appropriate risk perception and decision-making processes.

Research Questions

1. Are there differences in risk perception and decision-making about home safety hazards based on study group assignment (experimental versus control), individual characteristics, or type of health profession? Measures of risk perception and decision-making include the following:
    a. Frequency and severity of hazards detected in the virtual training simulation
    b. Affective reactions to perceived risks of home health hazards
    c. Indication of importance of detected hazards
    d. Types of decisions about managing detected hazards.
2. How do health care professionals prioritize the importance of detected hazards?
3. Are there differences in risk perception and decision-making about home safety hazards between study participants who are assigned to the experimental group and home healthcare expert clinicians who complete the VSTS?
4. What are the perceptions of health providers about the usefulness and feasibility of the final VSTS?

Method - Aim 3

The VSTS developed was tested using a randomized between and within-subjects design to determine its efficacy for training HHWs to recognize, assess, and respond to hazardous conditions in patients' homes (Figure 7).

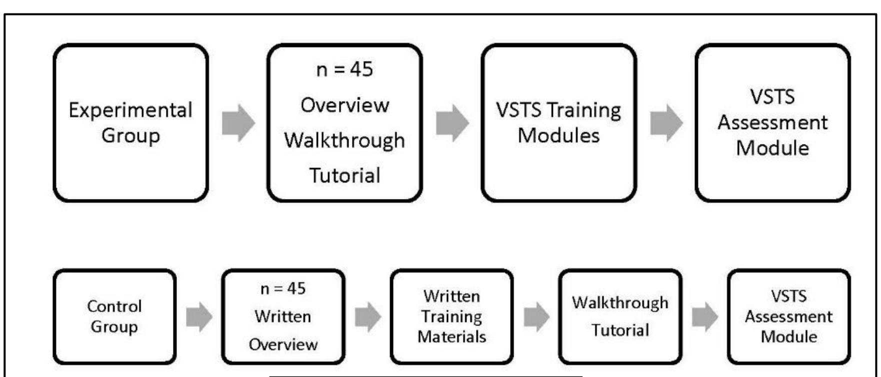

Fig. 7 Aim 3 Design

<u>*Participants.*</u> HHWs and students enrolled in health profession programs (nursing, occupational therapy (OT), physical therapy (PT)). *Inclusion Criteria*: Home healthcare professional (nurse, occupational therapist, physical therapist, home health aide) whose primary job was working in home healthcare, or student enrolled in a health profession program (nursing, OT, PT). *Exclusion Criteria:* HHWs who participated in Aim 1 or Aim 2 activities were excluded from participating in Aim 3. Participants answering

Procedures. The experimental group was exposed to the VSTS Training Modules. The virtual simulation was viewed on laptop or desktop computers. The training program lasted approximately 2 hours. The comparison group was provided with a written hard-copy version of the hazards included in the virtual training simulation, the rationale for why the identified hazards are potentially harmful to health care professional health/safety, and information on what to do about the hazards. Both groups complete the post-test (VSTS Assessment module). The post-test lasted about 30 minutes.

Figure 8. Series of dialogue boxes in the VSTS Electric/Fire/Burn training module concerning identifying the hazard of an oxygen concentrator positioned near a space heater and learning what to do about this hazardous situation.

Developing the written hard-copy version required extensive re-working of the content provided in the VSTS to provide those in the control group with similar content that is not as context specific as the information presented in the VSTS. For example, in the VSTS hazards are presented within a context of a specific home healthcare scenario and situation. The context of the hazards is not included in the hard-copy 'usual' training version. Figure 8 illustrates the dialogue boxes associated with a hazardous situation of an oxygen concentrator located close to a space heater. The trainee in the VSTS arm visually sees the hazard in the context of a patient's bedroom and is presented with information about why it is a hazard and what to do about the hazard. Participants in the 'usual care' arm read the same information that is void of the visual context of the VSTS (Figure 9). A hard-copy version was developed for each of the three training modules (Fire/electric/burn; Lift/trip/slip; Environmental).

What to look for: *Space Heater with Flammable Objects Nearby*

Q: Why is this hazardous?
A: A space heater near flammable materials, including newspapers, towels, or curtains, is a fire hazard. A space heater also has a motor. Appliances with motors can generate sparks, which can cause a fire in an oxygen-rich environment (i.e. a home in which oxygen is in use).

Q: What should you do?
A: Move the flammable objects away from the space heater or move the heater away from the objects. If your client uses a home oxygen concentrator, a space heater should not be placed within 10 feet of where oxygen is in use in the home. Hair dryers and other small appliances with motors (any motor can generate a spark) should also not be used within 10 feet of where oxygen is in use in the home. Explain the risks of keeping heat-producing appliances close to oxygen machines and work with your client to move the oxygen concentrator to a more open area away from heat sources. Cords should never be bound by a twist-tie, because that may cause the cord to overheat and cause a fire.

Fig. 9. Sample text from the paper version of the Electrical/Fire/Burn hazard information sheet, concerning the hazards posed by space heaters.

Assessment Module. The Assessment module introduces participants to a unique case scenario (60-year-old male paraplegic who is a diabetic on insulin with poor hygiene and poor eating habits; uses a wheelchair, sleeps in a hospital bed in the living room; lives with his mother who is a smoker on oxygen; owns a dog). There are 27 hazards in the Assessment Module: 9 from each of the three hazard categories. There are also non-hazards participants can select. Participants are asked to identify the hazards in the home, indicate why it's a hazard, and what to do about the hazard. Specifically, for each item that is selected, participants are asked if it is a hazard (yes/no), if it is a hazard, a dialogue box listing 3-4 reasons why it is a hazard is displayed. Participants are asked to check all the correct responses. Then a dialogue box is displayed with 3-4 action steps to take. Participants are asked to check all that apply. Figure 10 illustrates the format of the Assessment module hazards for one hazard (clutter on steps).

Think-Aloud Protocol. A "think aloud" protocol was used with a subsample of participants to gather formative and in depth cognitive information processing data on participant perceptions of: (1) hazard characteristics, (2) beliefs about (hazard) information usefulness (importance) for responses to hazards, and, (3) affective responses to risk, as represented in the VSTS Assessment module. A systemic sequential sample from experimental and control groups, respectively, was selected to do the think aloud protocol. Participants were randomly placed into one of four rooms in the VSTS: living room, kitchen, 1st floor bedroom, 1st floor bathroom.

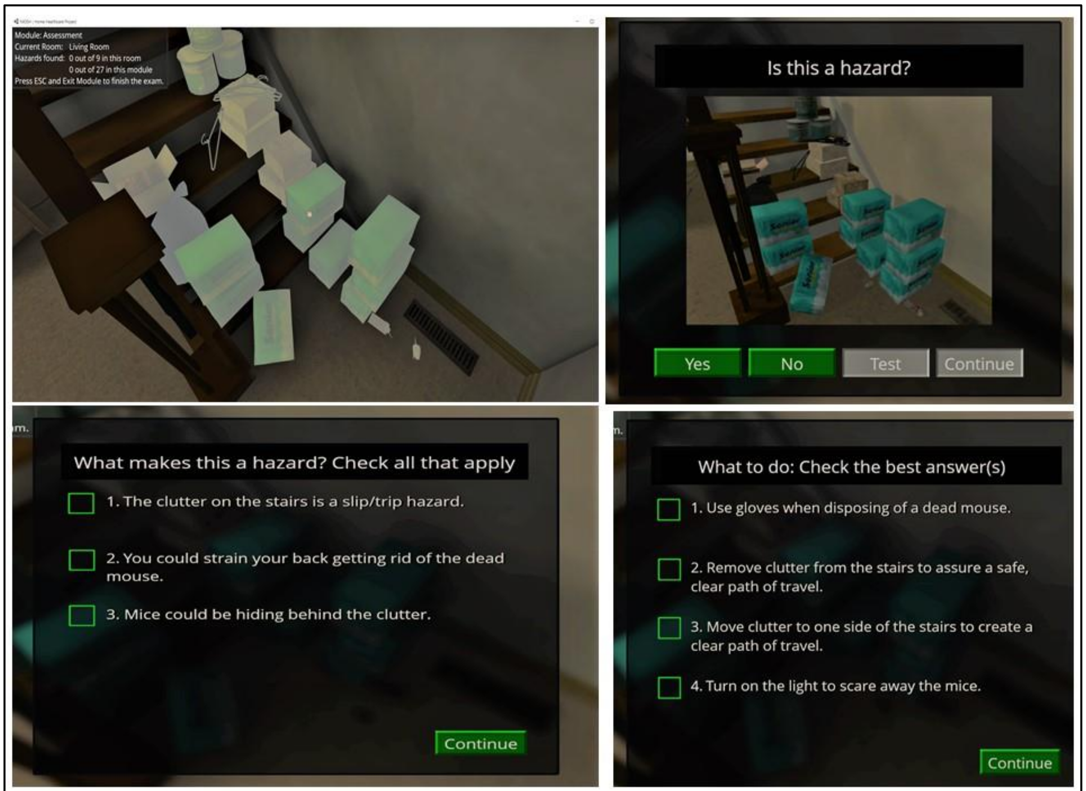

Fig. 10. Example of Assessment module hazard and required

Each participant was navigated to their randomly assigned room by the interviewer, and then instructed to identify a perceived hazard for discussion with the interviewer, but without selecting the identified hazard, so that the interviewee received no VSTS or interviewer feedback about the accuracy of their perceptions about the identified hazard. The interviewer used a semi-structured interview script with open-ended questions and structured probes to elicit information about risk perceptions and hazard management decision-making. Each participant discussed at least two identified hazards, and up to 13 specific hazards/participant were discussed, depending on time feasibility. Following the completion of the cognitive interview, each participant then proceeded to complete the remainder of the post-VSTS assessment module.

The "think aloud" cognitive interviews were audiotaped, transcribed verbatim, validated for accuracy, independently coded by two research team members, with coding discussed and reconciled by consensus to 100% agreement. The following data were coded for analysis:

- Types of hazards identified and discussed by room in virtual home
- Overall accuracy of hazards identification
- Coding for accuracy of dimensions risk perceptions (3-point 0 to 2 scoring)
    - Harm likelihood (*How likely are you to be harmed by this hazard*?
    - Absolute and relative severity (*How severe is the harm likely to be? How hazardous is it compared to other discussed hazards*?)
    - Frequency of occurrence (*How often do you see this type of hazard?*)
    - Level of concern and feelings (*How important is this hazard? What feelings if any do you have about this hazard?*)
- Coding for quality of described hazard management decision-making ("what to do") - coded into categories of Suboptimal, Mixed, Optimal

Aim 3 Measures. *Pre-training assessment*: Participants completed the Modified Home Healthcare Worker Questionnaire (M-HHCW) (professional version or student version, based on status as a non-student or student). *Post-training assessment*: Participants completed the Usefulness, Usability and Desirability (UUD) Assessment and the VSTS Assessment Module. Participants also participated in a post-training debriefing to discuss their experience, answer any questions that arise from their UUD, and ask any follow up questions they might have. All participants received a $50 gift card.

Data management and analysis. Responses for the M-HHCW questionnaire and the UUD Assessment were entered into an SPSS-PC database and used to characterize the study sample and participant views on the usefulness, usability, and desirability of the simulation. To explore differences in the efficacy of the VSTS, participant percentile scores in the Assessment module total scores were calculated and compared between the experimental and control groups, as well as by participant type, age category (<=29 years old/30+ years old), years of home healthcare experiences (<=5 years/>=6 years) gaming experience (yes/no), and comfort with computer technology using ANOVA. Descriptive statistics were calculated for each question about the UUD of the training simulation, but no formal inferential testing is planned. Alpha was set at 0.01 to control for Type 1 errors.

Results - Aim 3

Ninety-four total HHW/students participated in Aim 3 efficacy testing. However, demographic data were obtained from 93 participants. Most participants were female, white, and worked as a home healthcare aide/homemaker, or were a student in a healthcare profession (OT, PT, or RN) (Table 6). There were 52 (56%) in the experimental group, 38 (41%) in the control group, and 3 (3%) who completed the paper training and paper assessment due to reporting simulation sickness symptoms. There were no differences between the experimental and control groups with regard to gender, race, or job type. Participants in the experimental group were significantly older (41 yrs. vs. 32 yrs. p=.006) and had worked in home care longer (12.5 yrs. vs. 6.4 yrs. p=.03).

Table 6. Aim 3 - Demographic characteristics (N=93)

Characteristic	n (%)
Profession	
Physical therapy	1 (1.1)
Registered Nurse/LPN	5 (5.4)
Home healthcare aide/homemaker	44 (47.3)
Administrator	4 (4.3)
Student	39 (41.9)
Female	83 (89.2)
Male	10 (10.8)
Asian	1 (1.1)
Black/African America	21 (22.6)
White	71 (76.3)
Age (M, SD)	37.9 (15.7)
Years in home healthcare (N=56) (M, SD)	11.2 (10.5)

Training Modules – Identification of Hazards

Participants in the experimental arm of Aim 3 were asked to complete the three training modules and the assessment module. In the training modules participants search for hazards in the virtual home. Once a participant selects an item, they are asked to identify if the item is a hazard and, if it is a hazard, the training program then explains why it is a hazard and what they should do about remediating the hazard.

Participants were trained to use the VSTS by using the introductory modules (shown in green in Figure 6, right side). Participants then proceeded through the training modules by searching for hazards and reading the information presented with item selected. When an item is selected, the program asks the user if the item is a hazard. The user has a choice of answering either “yes” or “no” by selecting the appropriate button.

Table 7. Hazard analysis matrix using a signal detection nomenclature

Participant Response	Hazard?	
	Yes	No
Yes	1. Hit	2. False Alarm
No	3. Miss	4. Correct Rejection

The data analyzed in this section are from the three training modules, specifically, the hazards in the living room, bathroom, hallway, kitchen, and basement. Forty-nine participants in the experimental group completed at least one of the three training modules.

Similar to a signal detection approach, the percentages in each of the four cells shown in Table 7 were computed. The numbers of interest were the percentage of participants in cells 1 (Hit) and 3 (Miss), and the p percentage of individuals who did not select the hazard at all. This may have happened because the participant did not perceive the item to be a hazard, or they did not notice hazard.

Lift, Slip, and Trip Hazards. Figure 11 shows the lift, slip, and trip hazards identified in the living room. Participants did not correctly identify the low sofa (lifting hazard) 21% of the time, the coffee table which increases awkward postures making it difficult to assist clients on the couch was not detected 14% of the time, and the stacked blankets on the couch (clutter) were not detected 17% of the time.

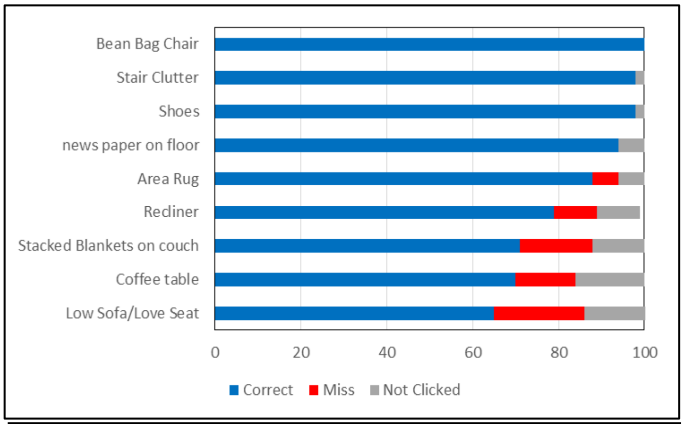

Figure 11. Lift/ slip/ trip hazards in the living room.

Figure 12 shows the lift slip and trip hazards identified in the bathroom. Twenty three percent missed the towel rod as a hazard and an additional 25% did not select the towel rod. Patients are likely to use the towel rod as an assist, but it is not designed to support these types of loads, leading to patient falls and home healthcare worker injuries as they attempt to prevent the fall and assist the patient off the floor. The low toilet was not perceived to be a hazard by 17 % of the people who selected it, and was not selected by 18% of the sample. Many of the items located in proximity to the toilet were hazards as they limit caregiver access to the patient when assisting with toileting. This included the scale, the trashcan, and the magazine box.

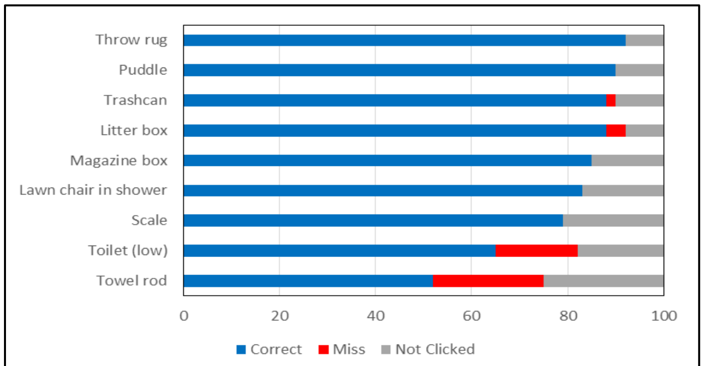

Figure 12. Lift/slip/ trip hazards in the bathroom.

In the kitchen, the hazard that was overlooked the most (not selected by 13% of the sample) was the pet food/water bowl, which was a hazard since it was essentially in the path of travel. Likewise the cat was a trip hazard that was not identified as such by 7% of the participants. In the hallway, 23% of the participants failed to select the bookshelf which effectively narrows the path of travel, and the same percentage failed to select the cat toys (trip hazards) laying on the floor. The rug in the hallway, a trip hazard, was not selected by 21% of the participants. The stairs going to the basement lack a handrail in this training module. Ten percent of the sample did not select the stairs to indicate this was a hazard. Ten percent of the participants also did not select the laundry basket in the path of travel.

Fire/Electric/Burn Hazards. There were several fire/electric/burn hazards in the living room (Figure 13). All participants who selected the cord under the rug, the unattended candles, the smoldering cigarettes, the non-working smoke alarm, the outlet falling out of the wall, and the frayed electrical cord correctly identified as hazards. However, a notable percentage of participants failed to select the smoke alarm (24%), the outlet (37%), and the frayed electrical cord (45%), indicating that these hazards might be overlooked. About 26% of participants that selected the non-displayed oxygen in use sign did not realize this situation represents a hazard.

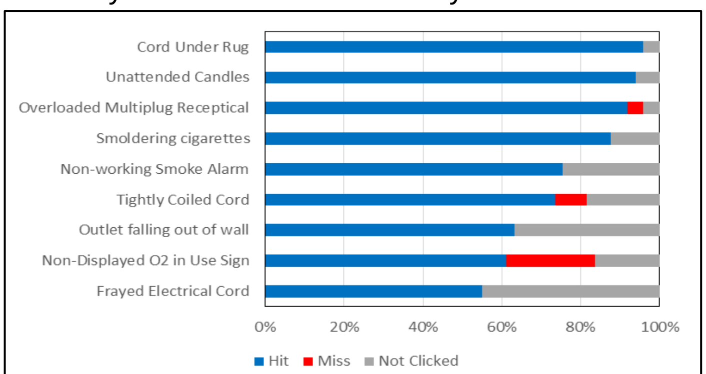

Figure 13. Fire/electric/burn hazards in the living room.

In the bedroom, the most challenging hazards to detect were the oxygen tube in the mattress, the lava lamp, the daisy-chained power strips, and the over-loaded power strips (Figure 14). The static electricity in the bedding materials in this oxygen rich environment was not considered to be a hazard by 16% of the participants. Among the fire/electric/burn hazards in the kitchen (Figure 15), the lowest "hit" rate was where there were two heat producing appliances plugged in the same outlet. When this hazard was selected, 23% of the participants did not initially indicate this situation represented a hazard. Surprisingly, 13% did not perceive the expired fire extinguisher to be a hazard. The most salient hazards, the stove burner left on, the space heater by the newspapers, and the grocery bag on the stove were identified by 90% or more of the participants.

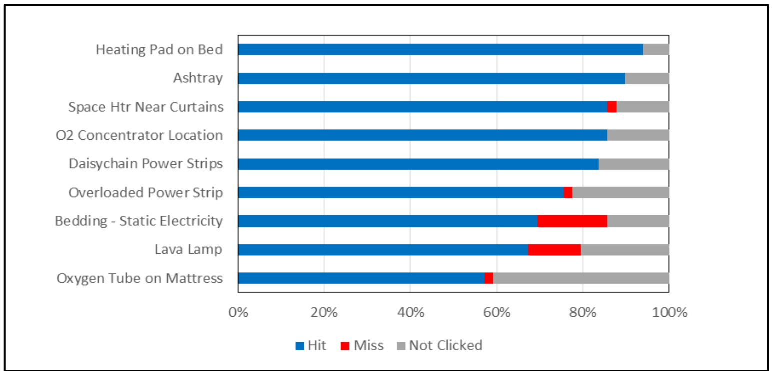

Figure 14. Fire/electric/burn hazards in the bedroom.

In the bathroom, fire/electric/burn hazards encountered during the training included an overloaded outlet and the space heater near a water source. These were correctly identified by as hazards by nearly all those who selected these items. However, 12% and 16% of participants failed to select the outlet and space heater, respectively. An additional hazard in the bathroom was the temperature of the hot water was too high. Only 57% of the participants selected the faucet.

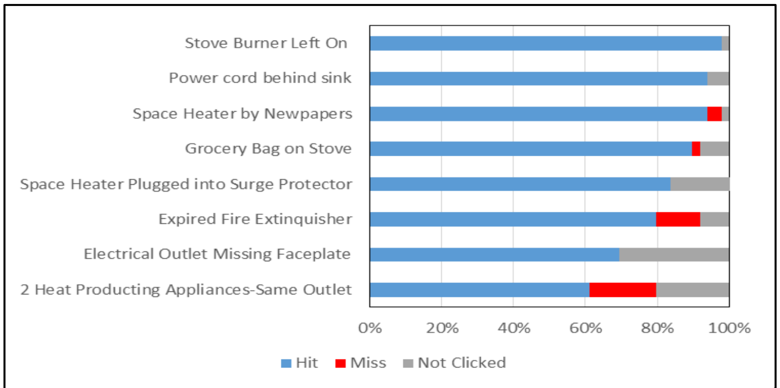

Figure 15. Fire/electric/burn hazards in the kitchen.

There were also two hazards in the hallway closet. The first was lightbulb that hangs close to linens, potentially creating a fire hazard. The second was an oxygen tank stored in the closet. More than a third if the participants failed to select these hazards. Perhaps they never opened the closet door. While nearly all who selected the lightbulb identified it as a hazard, 18% did not realize that storing an oxygen tank being in an enclosed area is a hazard.

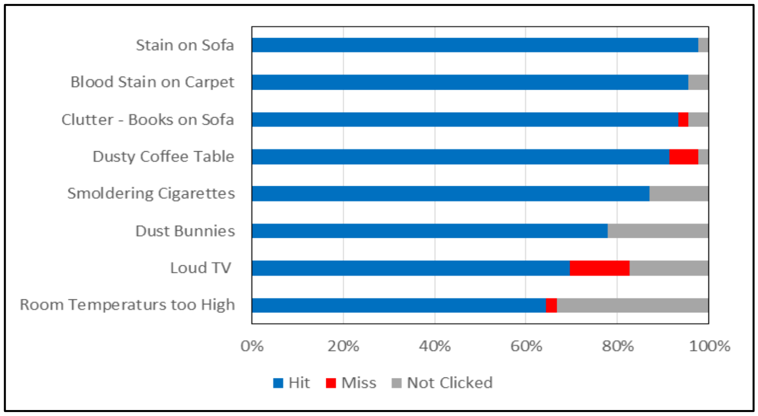

Figure 16. Environmental hazards in the living room.

Environmental Hazards. In the living room there were eight environmental hazards. Nearly all participants selected the stains on the sofa and on the floor (Figure 16), as well as the clutter on the couch and the dusty coffee table. However, 7% of those selecting the coffee table did not recognize it to be a hazard. "Dust bunnies", when spotted were identified as a hazard. Two of the more difficult hazards to detect in the simulation were the loud TV and the very high room temperature. These would be more salient if one were in the real environment. In the VSTS one cannot feel the temperature of the home or detect the loudness of the TV as the computer's volume setting may mask this cue.

In the bedroom (Figure 17), the dirty commode and dirty dog pad were selected by 86% and 89% of participants. Eighty two percent selected the waste basket and the bedbug stains. For all of the aforementioned hazards in the bedroom, those selecting the hazards correctly identified that the item was indeed a hazard. Only 69% of the participants selected the large, unstable TV as a potential hazard. Of those that did, 14% did not recognize this as a hazardous situation.

In the kitchen, over 90% of participants detected the spoiled food, the bug spray on the counter, the roach feces, the dead mouse in the mouse trap, and the needle sticking out of the trash bag as hazards (Figure 18). The lack of a carbon monoxide monitor with the gas stove was missed as a hazard by approximately 10% of those who selected the stove. Seven participants failed to select the unlabeled squeeze bottle, and one participant did not believe this to be a hazard. The broken glass in the sink was correctly identified as a hazard all who selected it, however, 18% did not select this hazard. The lowest detection rate was with the overloaded cupboards from which there were falling objects if the door was opened. It appears that 41% of the participants did not open the cupboard door when exploring the kitchen.

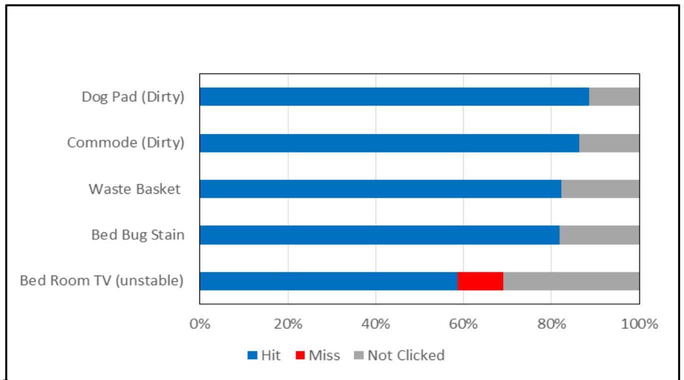

Figure 17. Environmental hazards in the bedroom.

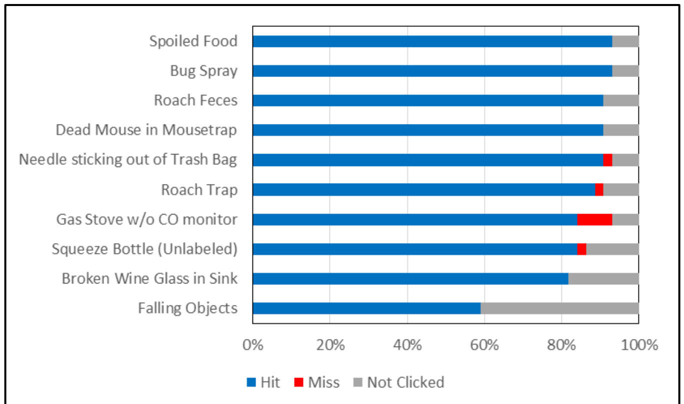

Figure 18. Environmental hazards in the kitchen.

The most difficult environmental hazards to detect in the bathroom were the plug-in air freshener (not selected by 27% of participants) and the empty soap dispenser which was not selected by 16% of participants and not considered a hazard by 9% of those that did select this hazard (Figure 19). While 89% identified the moldy shower curtain, only 76% identified the moldy tub as a hazard. To catch the latter hazard, participants would need to open the shower curtain (by selecting it) and then look in the tub. Twenty-two percent never selected this item.

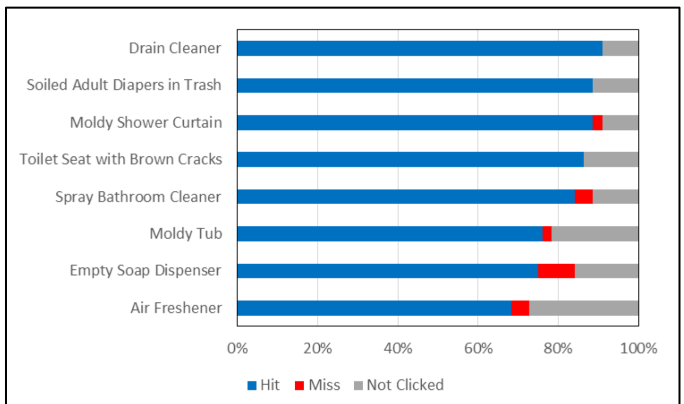

Figure 19. Environmental hazards in the bathroom.

Other environmental hazards in the home included a mouse trap, an open jar of paint thinner, an open bleach bottle, and poor lighting in the basement. These hazards were only selected between 73 and 86% of the time. The open bleach bottle and the poor lighting were both incorrectly identified as non-hazards by 7% of participants. The poor lighting was also a problem in the home's hallway, but it was only identified as a hazard by 61% of the participants. Nail heads, from nails that had been previously used to hang picture frames in the hallway, were not detected by 30% of participants. In the upstairs bedroom, the water damage on the ceiling and the black mold on the wall were only detected by 73 and 80% of participants, respectively.

Efficacy Testing

Complete Assessment module results were obtained for 74 participants (38 in the experimental group; 36 in the control group). The remaining 19 participants were unable to complete the Assessment module for varying reasons, the most common being lack of time due to other personal and work commitments. Most participants completing the Assessment module were female (86.5%), White (81.1%), and healthcare professional students (52.7%). About 38% of these participants were home healthcare aides/homemakers. Their average age was 34.1 years (SD=14). The average length of time in home healthcare for the 34 participants currently working in the field was 8.25 years (8.1). There were no significant differences between the 38 in the experimental and the 36 in the control group with regard to demographic variables.

To determine if there were differences between the experimental and control groups with regard to hazard identification in the Assessment module, only the hazards selected by participants were considered (e.g.

participant did not select the water on the floor in the kitchen, this hazard was not considered in the following analysis). This allowed us to determine the accuracy of participants' ability to indicate if something they identified in the home was/was not a hazard, and subsequently why it was a hazard, and what to do about the hazard. We determined the following four parameters: (1) Hazards correctly identified as a hazard (Hit), (2) Non-hazards correctly identified as a non-hazard (Hit), (3) Hazards incorrectly identified as non-hazards (Miss), and (4) Non-hazards incorrectly identified as a hazard (Miss).

Table 7. Hazard identification responses (N=74)

Experimental Group (n=38)	Actual Hazard (+)	Actual Non-Hazard (-)
Identified as a Hazard (+)	98.1% Hit	52.4% Miss
Identified as a Non-hazard (-)	1.9% Miss	47.6% Hit
Control Group (n=36)	Actual Hazard (+)	Actual Non-Hazard (-)
Identified as a Hazard (+)	96.4% Hit	39.5% Miss
Identified as a Non-hazard (-)	3.6% Miss	60.5% Hit

Table 7 illustrates the percentage of hazards correctly identified by participants in the experimental and control groups. The experimental group identified 24.2 (SD=2.9) hazards, while the control group identified 24.8 (SD=1.7) hazards. Although there were no significant differences between the groups, the experimental group correctly identified a greater percentage of hazards, yet they also incorrectly identified a greater percentage of non-hazards as hazards (a miss). While this pattern may appear of concern, further exploration revealed that the experimental group only selected an average of 4.7 (SD-3.2) non-hazards, while the control group selected significantly more non-hazards (M=10.8, SD=5.3, t=5.9, p<.001). Overall, these findings indicate that the experimental group was able to more accurately discern hazards in the VSTS.

There were no significant differences in identification of hazards in the Assessment module based on type of job (home healthcare aide/homemaker, other home healthcare workers, students), age group (≤29 years, 30+ years), years in home healthcare (≤5 years, 6+ years), computer gaming experience (yes/no), or comfort with computer technology.

Table 8. Percent correct responses to Why a hazard, and What to do about the hazard.

	Experimental (n=38)	Control (n=36)
What makes this a hazard?	86.2%	89.0%
What to do about the hazard?	81.8%	87.9%

There were no significant differences between the experimental and the control groups regarding responses to the 'What makes this a hazard' or the 'What to do about the hazard' items (Table 8). There were also no significant differences in response to these items based on age or gaming experience. However, students responded correctly significantly more often to the 'Why' items compared to other HHWs (nurses, administrators). Students also responded correctly significantly more often to the 'What to do' items compared to all other participants.

Table 9. Percent correct responses to Why and What to do items based on job type.

	All other professions (n=7)	Home healthcare aides (n=28)	Students (n=39)	Significance
What makes this a hazard?	77.6%[b]	86.4%	90.1%[a]	F=6.0; p=.004
What to do about the hazard?	72.4%[b]	81.4%[b]	88.5%[a]	F=11.4; p<.001

[ab]: Sig. differences by group

Exploration of correct responses by the three hazard types revealed that the Experimental and Control groups were able to identify over 90% of the hazards across hazard types. Participants in both groups also identified the slip/trip/lift 'Why' and 'What to do' items more often than the other two hazard types (electric/fire/burn; environmental). This may reflect more emphasis on these hazards in general HHW training and that they are the more common hazards in client homes (e.g., throw rugs).

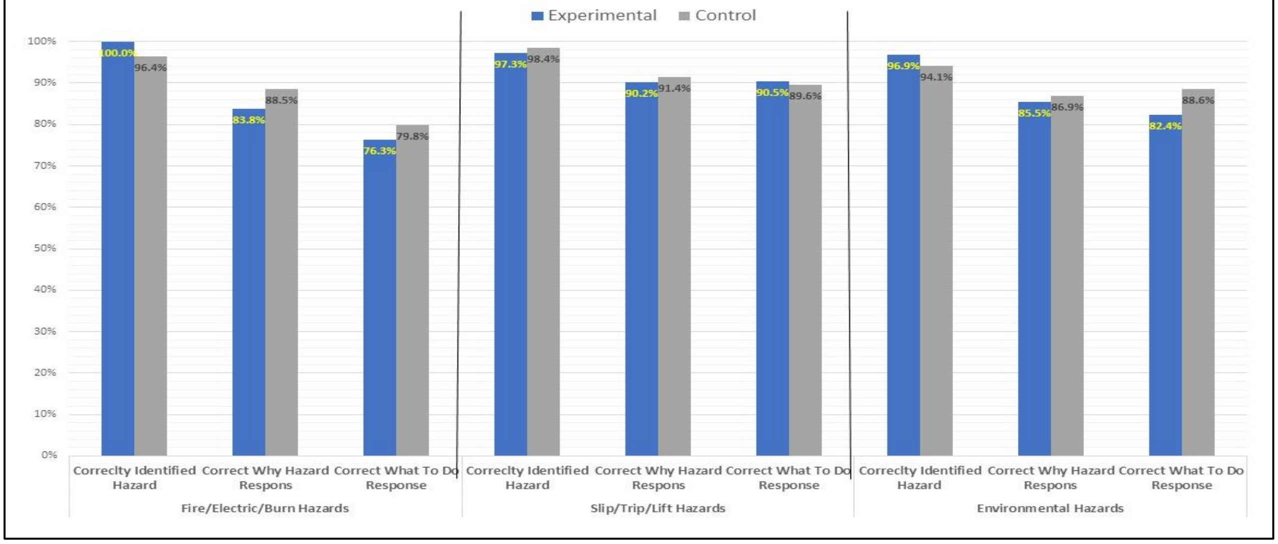

Fig. 11. Percent correct responses to item hazard identification, why it's a hazard, and what to do about the hazard, by type of hazard

"*<u>Think Aloud" Cognitive Interview Study Results</u>*

As Part of Aim 3, the accuracy of participant risk perceptions and decision-making were examined using mixed 'think aloud' qualitative cognitive interviewing and quantitative ratings of risk perceptions and quality of decision-making in a randomly-selected subset of 20 participants. The overall focus of this analysis was on gaining a detailed understanding of the specific mechanisms of impact of the VSTS for improving hazard risk perceptions and quality of hazard management decision-making. The need for this analysis as part of efficacy testing was based on our Phase I work that documented that HHWs were generally aware of home health and safety hazards to themselves, yet most self-described hazard management decisions that were less than optimal, including "making do" decisions representing suboptimal hazard management approaches ((Polivka et al., 2015; Wills et al., 2016).

Table 10. "Think Aloud" Sample Characteristics (n = 20)

	N (%)
Profession	
Home health aide	6 (30%)
Home health aide/OT student	3 (15%)
Nursing student	8 (40%)
Home healthcare manager	2 (10%)
Gender	
Female	19 (95%)
Male	1 (5%)
Race	
Asian	1 (5%)
Black/African American	1 (5%)
White	18 (90%)
Age (M, SD)	3.4 (SD=11.3)
Years of experience (M, SD)	7.9 (SD=9.5)

The Griffin et al. (Griffin et al., 1999) model that guided the analysis described seven types of factors influencing information processing about risks (hazards), of which five were a focus of the 'think aloud' analysis: individual characteristics, perceived hazard characteristics, affective responses to risk, information sufficiency, and beliefs about information usefulness (importance). VSTS-hypothesized mechanisms of change (impact) within the Griffin et al. (1999) model included the following:

- Individual characteristics (in terms of relevant hazard experience and quality of hazard management decision-making prior to VSTS training), and information sufficiency, are favorably influenced by VSTS training
- VSTS training influences perceived hazard characteristics (including accuracy of risk perceptions), affective responses to risk, and beliefs about information usefulness
- Accurate perceived hazard characteristics (including accuracy of risk perceptions) appropriate affect responses concerning risks, and accurate beliefs about information usefulness favorably influence health and safety behaviors in home healthcare (= effective hazard management actions).

Twenty (20) randomly-selected VSTS efficacy trial participants (21.3% of n = 94 participants) participated in the "think aloud' cognitive interview. These 20 participants were randomly assigned into one of the four main rooms of the post-training VSTS assessment module in the virtual home, as follows: (a) bathroom – 2/20

(10%); (b) bedroom – 7/20 (35%); (c) kitchen – 6/20 (30%); and, (d) living room – 5/20 (25%). Table 10 provides the sample characteristics of the 20 participants in the "think aloud" cognitive interview.

Participants discussed 80 discrete hazard management decisions, within which there were 85 specific hazards. All participants discussed at least two hazards, and most discussed more than two hazards. Some hazards were codable for multiple types of hazards; e.g., unbagged trash on the floor in the kitchen could be coded as both an environment and a slip/lift/trip hazard. Of the discussed hazards, 37 (43.5%) were electric/fire/burn hazards, 27 (31.8%) were environmental hazards, and 21 (24.7%) were slip/trip/lift hazards. Table 11 presents the distribution of identified hazards by type of hazard and room in the virtual home. Identified

Table 11. Number (%) of participants identifying types of hazards in the "Think Aloud" by VSTS room.

	Bathroom	Bedroom	Kitchen	Living Room
Electric/Fire/Burn Hazards				
Oxygen combustion hazards: Smoking with oxygen; Oxygen on extension cord/ungrounded; Oxygen proximal to space heater; Unattended flame or heat sources.	1 (2.3%)	3 (6.8%)	-----	-----
Unattended: candle, Iron; Lit cigarette; Uncovered light bulb;	1 (2.3%)	10 (22.7%)	-----	-----
Other combustion hazards: Paper towels on stovetop; Overloaded electrical cord or outlet; Space heater on extension cord or too close to flammable items	2 (4.5%)	8 (18.2%)	5 (11.4%)	-----
Missing or non-working safety items: Unposted oxygen in use; Expired fire extinguisher; Non-working smoke detector	-----	3 (6.8%)	2 (4.5%)	2 (4.5%)
Environmental Hazards				
Sanitation hazards: Bio-spill, body fluid exposures, uncleaned commode, soiled clothes	1 (3.1%)	1 (3.1%)	------	9 (28.1%)
Wound/infection hazards: Uncapped needles; Unsecured unsheathed knives; Broken glass; Hot beverage burn (if spilled); Exposure to unbagged trash; Animals: Dog, bed bugs/insects, rodents	------	------	9 (28.1%)	------
Chemical hazards: Unlabeled bottle (unknown contents); Bottles of bleach	------	------	4 (12.5%)	------
Sensory hazards: TV noise; Smelly trash	------	1 (3.1%)	1 (3.1%)	1 (3.1%)
Slip/trip/lift hazards		-----	5 (19.2%)	-----
Slip hazards: Unsecured throw rug; Water on floor	1 (3.8%)			
Clutter hazards: Furniture, Hoyer lift, newspapers, trash, open drawer in path of travel	1 (3.8%)	-----	7 (26.9%)	3 (11.5%)
Assorted musculoskeletal injury hazards: Poor lighting; Out-of-reach items; Bed too low; Clutter on bed	-----	4 (15.4%)	-----	-----

electrical/fire/burn hazards included oxygen combustion hazards for home oxygen use, unattended flame/heat sources, other combustion hazards, and missing or non-working safety items pertaining to electric/fire/burn safety. Environmental hazards included sanitation hazards, wound/infection hazards, and chemical and sensory hazards to the worker. Slip/trip/lift hazards encompassed a number of slip, clutter, and assorted musculoskeletal injury hazards.

Overall Accuracy of Risk Perceptions. Post-VSTS training, the overall accuracy of hazards identification was high, as consistent with the favorable impact of the training for supporting information sufficiency. All 'think aloud' participants (100%) identified actually-hazardous specific hazards, and none (0%) identified non-hazardous situations as hazardous.

Frequency of Hazard Occurrence. Participants tended to identify hazards that they also reported as seeing 'sometimes' to 'a lot' in their actual home healthcare work (M = 1.3/2).

Level of Concern and Feelings. If participants reported any feelings associated with identified hazards, all reported only negative feelings; e.g., fear, disgust, etc., and also tended to rate discussed hazards as ‘somewhat’ or ‘very’ important/concerning (M = 1.4/2).

Harm likelihood. Participant perceptions were calibrated with objective likelihoods of harm, and participants also tended to identify hazards that were ‘somewhat’ to ‘very likely’ to cause harm (M = 1.5/2). For example, some participants correctly noted that fire/electric/burn hazards that actually caused a fire and/or electric shock could be ‘very likely’ to harm the worker.

Absolute and Relative Severity of Harm. Participants’ perceived extent of risks was generally calibrated with objective risks. For example, participants correctly noted that exposure to burning paper towels or a fire from an overloaded/faulty outlet was likely to be associated with severe injury potential, and also rated this risk as relatively more hazardous as compared to less ‘urgent’ hazards (e.g., an unlabeled bottle that does not need to be opened by the worker) and those hazards for which adequate exposure protection was available (e.g., use of gloves to avoid bio-waste exposure when cleaning up a bio-spill).

Hazard Management Decision Quality. Except for one instance in 80 discussed decisions, all participants otherwise discussed either optimal (88.8%; n = 71) or at least somewhat appropriate (10%; n = 8) decision-making about hazard management for all of the identified hazards. Optimal decisions were those that were effective in mitigating and/or otherwise managing the health hazard, that did not carry significant disadvantages for the worker or client, and which went beyond passive actions only (e.g., client education only), to addressing a specific action to be taken. For example, if a participant identified paper towels atop the stove as a fire hazard, an optimal management decision was to have stated that the paper towels would be removed from the stovetop. Mixed decisions were those that may or may not have been effective in mitigating and/or otherwise managing the identified hazard, and/or which involved significant tradeoffs for the worker and/or client. For example, if furniture clutter was identified as a hazard, coding of a mixed decision occurred if the participant indicated that s/he would personally move a heavy piece of furniture to alleviate the clutter, due to the risk of injury to the worker. A Suboptimal decision was coded if the described decision was ineffective or otherwise inappropriate; e.g., if the participant stated that s/he would continue to provide care to a client who was smoking with oxygen in use, which is a severe fire/explosion hazard.

Usability analysis

To answer our Aim 3 research question on overall system usability and feasibility, we analyzed data only from HHWs who completed the entire VSTS, including both training and assessment. This analysis allowed us to understand the usability of the system as a whole. To assess usability and feasibility of the VSTS, we evaluated the usefulness, (*value and applicability*), usability (*ease of use*), and desirability (*appeal or interest*).

Table 12. Experimental group participant characteristics for UUD analysis (N = 39)

Characteristic	Mean (SD)
Age (n=38)	42.53 (16.67)
Years in Homecare (n= 26)	14.44 (10.57)
Characteristic (N=39)	**N (%)**
Sex	
Female	35 (87.1)
Male	3 (7.7)
Not Reported	1 (2.6)
Race	
African-American/Black	13 (33.3)
Caucasian/White	26 (66.7)
Profession/Job Title (N = 39)	
Home Health RN/LPN	3 (7.7)
Home Health Aide/Homemaker	22 (56.4)
Student	13 (33.3)
Other	1 (2.6)

This usability analysis included 39 participants who were at least 18 years old, represented multiple disciplines, either were employed as a home healthcare professional or enrolled as a student in a health profession education program (nurse, OT, PT), and who passed a pre-screening assessment to detect susceptibility to simulation sickness (Table 12). Twenty-six HHWs and 13 students were included in the current analyses. Most participants were female and had an average of 14 years of experience working in home healthcare. Approximately 67% were Caucasian/white and 33% African American/black. Of the 26 HHWs, 85% were home health aides.

Overall, participants reported that the VSTS was useful and feasible. Over 83% of participants found the VSTS easy to use, over 94% agreed/strongly agreed the VSTS was useful, and over 80% liked it. In addition, over

82% of participants reported their co-workers would learn quickly and 84% reported their co-workers would like it. Ninety-seven percent reported the VSTS would keep workers safe and 70% reported that they wished their agency had it. Additional analyses revealed that the usability of the VSTS was not affected by computer use history or computer gaming experience, with only one exception: participants with limited gaming experience were less likely to report it was easy to move through the virtual home compared to those with moderate to a lot of experience ($X^2_{(1)} = 4.03$, $p = 0.045$).

Discussion

The overall purpose of this project was to develop and test the efficacy of an interactive, widely-distributable, virtual simulation training system using an interdisciplinary and participatory design approach. Using multiple methods, stakeholder engagement, and a rigorous iterative process, the project investigators created a virtual simulation training system that includes a tutorial and orientation, three training modules, and an assessment module that trains and assesses the ability of HHWs to identify and respond to health and safety hazards in client homes.

Several important findings emerged from the development process (Aim 1). Slip/trip/lift hazards, biohazards, and air quality were the most commonly described hazards by HHW, and slip/trip/lift hazards were the most commonly identified in every room of the home. That slip/trip/lift hazards were so pervasive is consistent with current BLS statistics. Of the 27,000+ injuries experienced by home healthcare workers (U.S. Bureau of Labor Statistics, 2015b), approximately half were sprain, strains, or tears with injury sources including floors, walkways, or ground surfaces (24%) and worker posture (12%) (Agbonifo et al., 2017; Cloutier et al., 2008; Schoenfisch et al., 2017; U.S. Bureau of Labor Statistics, 2015a). Other top hazards varied by room. For example, biohazards were most common in the kitchen and bathroom, while air quality and allergens were most common in the kitchen and bedroom. Also important were the findings regarding the quality of decision making. In the Aim 1 interviews, the majority of decisions described by HHWs about how to manage hazards were either mixed (may or may not have been effective) or suboptimal (ineffective; inappropriate; may not meet health needs of client or HHW). These decisions were influenced by the perceptions of HHWs about hazard characteristics, information sufficiency, professional culture (e.g. affective responses such as client needs superseding HHW health and safety), resources, and beliefs about information usefulness (Wills et al., 2016). These findings demonstrate that HHWs are aware of the hazards they may encounter but are likely to end up “making do” with hazard solutions that may be mixed hazard or clearly suboptimal and have the potential to contribute to worker injury and illness (Wills et al., 2016). Appropriate training, such as that provided by the VSTS, can provide HHWs with the information they need to make better informed decisions to protect their health. Other strategies to improve the health of HHWs move beyond training of the individual and include development, implementation, and enforcement of standardized policies at the agency level (e.g. no smoking policies) and adequate resources to make changes that may keep them safe (purchase of shower chair).

Efficacy testing of the VSTS involved both objective assessment of performance and also continued UUD assessment to understand the user experience. The data from the training modules showed that overall participants correctly identified most of the hazards, this analysis shows that many of the less salient hazards, for example low toilets and furnishings, are likely to be overlooked. While some of these may be more difficult to remediate, others may not be. Elevated toilet seats are commercially available, as are devices to raise furnishings. The training modules served to increase awareness of these hazards and possible remedies.

Unlike a typically occupational setting where the employer generally has control over the environment and the furnishings, home healthcare agencies are challenged in that their work environment is not under their direct control. Thus, hazard remediation has to engage the client and others who live in the home which presents its own set of challenges (Wills et al., 2015). Future developments in the VSTS training system will likely include tips on how to discuss these changes with clients.

Participants in the experimental group who completed all of the training modules as well as the Assessment module, were able to correctly identify more hazards as hazards compared to the control group (who received printed information concerning home hazards). Although these differences were not statistically significant, they did indicate that learning occurred in the virtual environment and our UUD assessment indicated participants found the VSTS useful, usable, and desirable (Darragh et al, in review). Even among those with limited computer gaming experience or consistent computer use the VSTS was accessible and usable, with slight qualitative differences in navigating the virtual environment and interacting with the hardware (Darragh et al., in review).

However, among participants as a whole, several usability issues did emerge. Qualitative analyses of comments from all users, whether or not they completed the entire training system, revealed some usability challenges. Some participants reported challenges with both the mechanics of selecting a hazard, "*Some hazards were very hard to click on,"* and whether they were able to select objects they believed were hazards, "*… exposed lightbulbs in the closets were told to be hazards, but you could not click on them in the module*." Some users found it difficult to find some hazards in the current VSTS, particularly less salient items such as an empty liquid soap dispenser. Thus, there is a need for the VSTS to provide assistance when needed, via hints about hazard types and locations, to speed the search process, allowing HHWs more time to attend to the essential content of the VSTS. While most reported few problems with moving through the simulated environment, some users also struggled with using computer hardware (keyboard, mouse) to navigate the virtual home and select (click-on) hazards. Common issues observed by the investigators included difficulty using the mouse to look around the environment and challenges with using the WASD or arrow keys to move forward, back or side-to-side. One participant expressed: "*I found the mouse control of direction I was facing to be a little frustrating and limiting, at times."* Refining the VSTS virtual reality (VR) version will allow a more intuitive interface that does not require the user to use a keyboard or mouse. Some participants did struggle with navigation.

The overall results of the "think aloud" cognitive interview for Aim 3 are consistent with favorable impact of the VSTS per the hypothesized direct and indirect mechanisms of change, for preparing HHW to recognize, assess, and respond to hazards using appropriate risk perception and decision-making processes. The favorable results include the 100% accuracy post-VSTS training for identifying actually-hazardous specific hazards. By contrast with the decisions described by HHWs in the Aim 1 work, except for one instance in 80 discussed decisions, all participants otherwise discussed either optimal (88.8%) or at least somewhat appropriate (10%) decision-making about hazard management for all of the identified hazards. Risk perceptions were accurately calibrated with actual relative risks and severity of harm from the identified hazards. The obtained results constitute a mixed qualitative-quantitative analysis of a randomly-selected subset of 20 (21.3%) of the 94 VSTS efficacy-testing participants but are consistent with the overall accuracy results for hazards identification in the full sample.

A majority of "think aloud" participants were assigned to the bedroom or kitchen (65%), and fewer assigned to the kitchen (25%) or bathroom (10%), which does likely impact the specific results. For example, more salient, easily noticeable, "urgent" types of hazards were identified more frequently, especially in the kitchen; e.g., unattended flame/heat and other combustion sources in the bedroom/kitchen, wound/infection and clutter hazards in the kitchen, followed by living room biohazards. Next research should further examine the role of salience of hazards, and order of exposure to rooms in the virtual home as a factor in achieving optimal accuracy of risk perceptions and hazard management decision-making. Additional VSTS enhancements may be needed to support identification and management of more subtle, complex hazards within the "whole" home; e.g., embedded systematic hazard search approaches, avatars for coaching, tips, role-playing.

An additional usability consideration is that the VSTS relies on a significant amount of written health and safety information. HHWs who have reading disabilities, limited literacy, or who do not like to read will benefit from an audio presentation. An estimated 10-21% of HHWs are Hispanic/Latino with Spanish as a first language (Bercovitz A, 2011; PHI: Quality Care Through Quality Jobs, 2014; U.S. Bureau of Labor Statistics, 2017), so a Spanish language version of the VSTS will support more widespread use. Finally, to support point-of-care needs, a searchable app will provide just-in-time information to help HHWs to identify evidence-based response strategies for client home hazards.

Given the positive usability results, and our goal of wide dissemination, we have created a website from which the VSTS can be downloaded at no cost (https://homehealthcaresafety.osu.edu/). The website provides down load instructions, instructions how to start the VSTS, and a survey where users can provide information that can be used for future improvements of the VSTS.

Conclusions

This project used a participatory design process to identify the key safety hazards encountered by HHWs as they work in client homes. This information was embedded into two versions of a virtual simulation training system**,** one capable of running on a normal computer and one using a three-dimensional virtual environment. With the immediate goal of developing a product that could be readily disseminated to home healthcare agencies, the system designed to run on normally available computer hardware was refined though extensive usability and efficacy testing. The final product of this work is a training system that the targeted end users enjoy working with as they learn about the hazards they will likely encounter as they work with clients, as well as feasible remediation approaches. Going forward, the product of this work will likely have significant impact on HHW safety as it can be easily downloaded at no cost and used by individuals with minimal computer experience.

Publications

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Peer-reviewed Presentations:

Polivka, B., Darragh, A., B. Wills, C., Lavender, S., Sommerich, C., & Stredney, D. (2017, June). Virtual Simulation Training in Home Healthcare. Paper presented at the 2017 NIOSH Expanding Research Partnerships: State of the Science Conference, Denver, Colorado.

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Wills, C.E., Polivka, B., Darragh, A., Lavender, S., Sommerich, C., & Stredney, D. (2015, Oct). Decision Quality and Educational Needs of Healthcare Personnel to Improve Decision-Making about Managing Home Healthcare Hazards. Poster presented at the 37th Annual Meeting of the Society for Shared Medical Decision Making (SMDM), St. Louis, MO.

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Wills, C.E., Polivka, B., Darragh, A., Lavender, S., Sommerich, C., & Stredney, D. (2014, September). Making do” decision-making among home healthcare personnel: implications for designing a virtual simulation training for assessing and managing home health hazards. Paper presented at the annual meeting of the Council for the Advancement of Nursing Science (CANS). Washington, DC.

1. Cumulative Inclusion Enrollment Table - Attached.

2. Gender and minority study subjects – included in Cumulative Inclusion Enrollment Table – Attached

3. Inclusion of children under the age of 21 years. There were two participants under the age of 21 (one was 18 years old; the other was 20 years old). Both were working in home healthcare as home healthcare aides and were therefore relevant to the study as working home healthcare providers.

Educational or training curriculum.

This project developed a virtual simulations training system (VSTS) to train home health care workers (HHW) to identify and respond to hazards they may find in client homes. The structural components of the virtual environment includes a simple 2-story dwelling with a partial basement. This virtual dwelling serves as a paragon for many typical living environments encountered by home healthcare professionals. Guided by information provided by our focus groups and expert interviews, we subsequently modeled the various assets, i.e., furniture, appliances, and sundry personal items typically found in a typical dwelling of a home healthcare patient. This VSTS includes three specific training modules focused on specific types of hazards HHW might encounter: (1) fire/electrical/burn hazards, (2) environmental hazards, and (3) slip/lift/trip hazards. An Assessment module incorporating all three types of hazards was also created to assess trainees grasp of hazard identification and response. Each training module and the assessment module addresses a different client scenario.

Trainees are introduced to the VSTS with Overview and Home Walkthrough modules. The Overview introduces the trainee to a Job Safety Analysis including an initial walk-through and a safety check of each room in the client's home. This is followed by an overview of the various components of the VSTS. The Walk-Through of the VSTS visually introduces the trainee to the layout of the home (various rooms and their locations) and how to manipulate through the VSTS to find the rooms, thus familiarizing trainees with all the structural aspects of the virtual home. A Tutorial is also included that instructs the trainee on how to move through the virtual home with the mouse and WASD or arrow keys.

During interaction and training with a specific training module, the trainee selects any of the myriad objects, or assets, found in the virtual environment, that to their knowledge may constitute a hazard. Selection of assets is accomplished by pointing to an asset in the scene. Upon selection, a dialogue box appears on the screen. Further interaction with the game is suspended to allow for interaction with the dialogue box. Users also have a flashlight and magnifier to examine conditions and hazards more closely. Assets such as fire alarms or water faucets can be tested as working/not working. If their selection is not a hazard, a brief justification is provided, and they are returned to the game. If the selection is a hazard, again a brief justification is provided. Subsequently, the user is provided additional information with regard to the selected hazard concerning why it's a hazard and what they could do to address the hazard. Additional information may include text, and/or image(s). All interactions and selections are tracked and stored in a single session file for each of the three training module and for the Assessment module.

There are 27 hazards in the Assessment Module: 9 from each of the three hazard categories. There are also non-hazards participants can select. Participants are asked to identify the hazards in the home, indicate why it's a hazard, and what to do about the hazard. Specifically, for each item that is selected, participants are asked if it is a hazard (yes/no), if it is a hazard, a dialogue box listing 3-4 reasons why it is a hazard is displayed. Participants are asked to check all the correct responses. Then a dialogue box is displayed with 3-4 action steps to take. Participants are asked to check all that apply. A final score indicating the correct number of hazards identified is visible to participant.

Materials for other investigators:

- The VSTS can be downloaded at no cost from the following website: https://homehealthcaresafety.osu.edu/
- Data requests can be submitted to the Principal Investigator- Dr. Barbara Polivka at barbara.polivka@louisville.edu
- Data can be made available without charge and without identifiers to those requesting access.

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Appendices

Electrical/Fire/Burn Training Sim (39 hazards)

Elizabeth is a 65-year-old female, 5 ft. 4 inches, 150 lbs. (BMI=26) She has COPD, is on continuous oxygen and she is a smoker.

Living Room
1. Tightly coiled cord for lamp by the door
2. Electrical cord under throw rug
3. Smoke alarm non-working
4. Frayed electrical cord
5. Outlet hanging
6. Lit candle
7. Overloaded multiplug receptacle
8. Oxygen in use sign on coffee table
9. Ashtray smoldering with O2 on

Kitchen
1. Missing faceplate on outlet
2. Stovetop burners left on
3. Plastic bag on stove w/burners on
4. Coffee pot cord behind faucet
5. Overloaded outlet with 2 heat sources
6. Space heater with newspapers nearby
7. Microwave- covered aluminum container of food in it inside microwave
8. Fire extinguisher - expired.
9. Space heater plugged into surge protector

Bedroom-Downstairs
1. Working smoke detector -Test by clicking
2. Ash tray on nightstand with smoldering cigarette butts
3. Space heater by curtain to right of the bed
4. Oxygen tube going into mattress
5. Lava lamp on dresser
6. Heating pad on bed, plugged in, turned on
7. Daisy-chained power strips
8. Overloaded power strip
9. Oxygen concentrator location
10. Bedding-static electricity

Bathroom-Downstairs
1. Overloaded outlet to right of sink
2. Space heater between toilet and sink
3. Vanity faucets
4. Facial tissues, hand wipes, lotion bottles atop toilet tank

Upstairs
1. Ashtray at top of stairs by chair
2. Iron cord plugged into extension cord
3. Ironing Board with Iron Turned on

Hallway
1. Hallway closet with linens on top shelf
2. Oxygen tank stored in closet

Basement
1. Lint sticking out of dryer door
2. Water heater set too high

Environmental Hazards Training Sim (43 hazards)

Joe is an 80-year-old, 5 ft. 10 in, 180 lbs. (BMI=26) He has poorly controlled insulin dependent diabetes, congestive heart failure, and neuropathy in his feet. He is a smoker, incontinent, lives alone with his black lab named Blackie. He can walk around in his home, but is weak and needs help with meal preparation, personal care, and cleaning. He does not like to open his windows for safety reasons.

Living Room:

1. Ashtray with lit cigarettes
2. Home too hot, digital thermostat set at 84
3. Dust bunnies on air return
4. Dust on coffee table with clean marks where partially cleaned
5. Clothes, magazines, papers on couch and loveseat - no place to sit or place your work materials
6. Soiled spots on uncovered areas of couch and/or loveseat
7. Red splotches (blood) on carpet
8. TV blaring loudly

Kitchen

1. Papers on kitchen chairs and counters- no clean place to sit or place work equipment
2. Gas stove in kitchen - no carbon monoxide monitor
3. Bug spray can visible
4. Open roach traps on the counter
5. Unlabeled squeeze bottle with liquid inside
6. Spoiled food on counter
7. Needle sticking out of trash bag
8. Spring mouse trap on floor with dead mouse
9. Roaches feces
10. Cans of food/other objects in overhead cabinets that tumble out of cabinets
11. Broken glass in sink
12. Fly paper hanging from ceiling

Bedroom

1. Soiled chux on bed
2. Bedside commode that has not been emptied
3. Dog droppings on puppy pad by bookcase
4. Reddish spots on mattress - bedbug residue
5. TV on dresser
6. wastebasket

Bathroom-Downstairs

1. Empty soap dispenser - no soap available;
2. Air freshener plugged into wall
3. Moldy shower curtain
4. Moldy tub
5. Drain cleaner open on vanity
6. Cracked toilet seat with brown in cracks
7. Spray bathroom cleaner on vanity or toilet or the floorSoiled adult diapers in trach can

Upstairs/Stairs

1. Black on walls by ceiling and window
2. Water damage on ceiling

Hallway

1. Nails sticking out of wall in hallway where a picture used to be.
2. Overhead light in hallway not working – no night lights

Basement

1. Poor lighting
2. Paint thinner in an open jar with paint thinner can next to it -on landing to basement stairs
3. Bleach container on washer - open with cap next to bleach bottle
4. Spring mouse trap on the floor

Front Steps into home

1. Dog barking as you are about to open the front door

Slip, lift, Trip Training Module – Hazard List (Total Hazards – 47)

Frank is a 66, 5 ft. 10 inches, 220 lbs. He is a Viet Nam veteran. He is married, and his wife continues to work full time. He needs supervision during the day while she is at work. He has a left sided paralysis from a recent stroke (about 1 month ago). He uses a wheelchair, and though he can propel it by himself using his right foot, he needs assistance to move it around corners, across carpets, and when he is tired. He needs help with transfers, showering, and toileting, though he likes to try to help. He was referred to home care for assistance with all Activities of Daily Living (ADL), light housekeeping and laundry, and medication management.

Living Room
1. Couch & loveseat too low
2. Coffee Table limiting access to client
3. Doll Cradle - clutter
4. Area rug under coffee table
5. Books/newspapers stacked on floor
6. Electric guitar, amplifier, cord
7. Recliner – lift hazard
8. TV tray next to recliner
9. Bean bag chair
10. Shoes at bottom of stairs
11. Stacked blankets on couch

Kitchen
1. Grease on floor
2. Water in front of fridge
3. Cracked Linoleum
4. Throw rug in front of sink
5. Cat bowls on floor
6. Cat on floor
7. Garbage bags & newspapers by back door

Bedroom-Downstairs
1. Bed
2. Hoyer lift
3. Stacks of books on the floor (by wall near dresser)
4. Overflowing laundry basket (by door)
5. Damaged carpet
6. Wheelchair

Bathroom-Downstairs
1. Toilet – no grab bars
2. Towel rod – no grab bars
3. Bathtub
4. Tile floor - puddle on floor
5. Litter box - across from toilet, next to tub
6. Box with magazines between toilet and tub - in front of toilet brush
7. Throw rug in front of vanity
8. Bathmat towel in front of tub
9. Bathroom scale tipped on side below toilet paper/trashcan
10. Glass shower door
11. Plastic lawn chair with arm rests chair in tub

Upstairs
1. "Depends" stacked loosely in bathroom
2. Visibly Thick throw rug at end of bed
3. Clutter on stairs going to 2nd floor

Hallway
1. Throw rug before bedroom door
2. Bookcase against wall between closet and bedroom
3. Cat toys right before the bathroom

Basement
1. Clutter on basement stairs landing and stairs
2. Poor lighting
3. Clothes in basket near dryer on floor
4. No railing on stairs
5. Dryer sheets on floor

Front Steps
1. Snow/ice on front steps

PHS Inclusion Enrollment Report

View Burden Statement

PHS Inclusion Enrollment Report

This report format should NOT be used for collecting data from study participants.

OMB Number: 0925-0001 and 0925-0002
Expiration Date: 10/31/2018

***Study Title (must be unique):** Home healthcare hazard training through virtual simulation

* Delayed Onset Study? ☐ Yes ☒ No

If study is not delayed onset, the following selections are required:

Enrollment Type ☐ Planned ☒ Cumulative (Actual)

Using an Existing Dataset or Resource ☒ Yes ☐ No

Enrollment Location ☒ Domestic ☐ Foreign

Clinical Trial ☐ Yes ☒ No **NIH-Defined Phase III Clinical Trial** ☐ Yes ☒ No

Comments:

Racial Categories	**Ethnic Categories**									
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			**Total**
	Female	**Male**	**Unknown/ Not Reported**	**Female**	**Male**	**Unknown/ Not Reported**	**Female**	**Male**	**Unknown/ Not Reported**	
American Indian/ Alaska Native	0	0	0	0	0	0	0	0	0	0
Asian	1	0	0	0	0	0	0	0	0	1
Native Hawaiian or Other Pacific Islander	1	0	0	0	0	0	0	0	0	1
Black or African American	24	2	0	0	0	0	5	0	0	31
White	114	8	0	1	2	0	2	0	0	127
More than One Race	0	0	0	0	0	0	0	0	0	0
Unknown or Not Reported	0	0	1	0	0	0	11	1	1	14
Total	140	10	1	1	2	0	18	1	1	174

Report 1 of 1

< Previous Report Delete Report **Next Report >**

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