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Evaluating Home Healthcare Workers' Safety Hazard Detection Ability Using:

VIRTUAL SIMULATION

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Abstract

Home healthcare workers (HHWs) are routinely exposed to occupational safety hazards when servicing patients in their homes that put them at risk for injury. These hazards can be broadly classified as "electric, fire and burn," "environmental," or "slip, trip, and lift" hazards. To better train HHWs regarding their potential exposure to these hazards, a home healthcare virtual simulation training system (HH-VSTS) was developed. The HH-VSTS contains three training modules, corresponding to the aforementioned hazard categories, and an assessment module. In each training module, the trainee must navigate the virtual space, via a mouse click, and identify items or conditions that represent hazards. Once an item has been clicked on, the HH-VSTS asks the user if the item or condition is a hazard. For items or conditions that are hazards, additional text boxes present material to the user as to why the item constitutes a hazard and potential remediation approaches. Thus, it is important that hazards be identified and clicked on for the trainee to receive the educational component of the training system. This article evaluated the ability of 49 HHWs to find hazards in each of the three categories. In all modules, participants found the most salient hazards (e.g., clutter on stairs, unattended candles, biohazard stains) but struggled to find some of the less salient hazards. Several less salient hazards included the pet food bowls in the path of travel, the frayed electrical cord, oxygen tube leaking into a mattress,

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hot water that was too hot, and elevated room temperatures. Overall, this analysis found that most of the hazards within the training modules could be found by naïve HH-VSTS users. These data suggest the need for including hints that guide users toward hazards with which they are less familiar.

Home healthcare workers (HHWs) are exposed to numerous safety hazards in patient homes that can result in injuries and lost work time (Gershon et al., 2008; Polivka et al., 2015). Howard and Adams (2010), based on an analysis of Washington State workers compensation claims, found HHWs had a 60% higher claims rate compared with workers in other industries. In 2016, the U.S. Bureau of Labor Statistics (BLS) reported that the overall rate of lost time injury in the home healthcare services sector was 36% higher (BLS, 2016a) than the overall rate for nongovernmental industries in the United States. In that year, 25,900 recordable injuries were associated with providing home healthcare (HHC) services in the United States (BLS, 2016b), and over 11,000 of those injuries resulted in lost workdays (BLS, 2016c). Nearly half the reported injuries were sprains, strains, and tears, and another 24% were classified as soreness and pain. The most frequent sources of injury were patients (e.g., patient handling) (28%), and floors, walkways, or ground surfaces (20%). Shnayder et al. (2018) reported 48% of their HHW survey respondents reported musculoskeletal pain within the last week, most often in the lower back, left shoulder, and neck.

Categories of hazards (electric, fire, and burn; environmental; slip, trip, and lift) to which HHWs are exposed in patient homes have been described in the literature (Gershon et al., 2008; Gershon et al., 2012; Markkanen et al., 2014; Polivka et al., 2015). HHWs need effective training to recognize these different types of hazards and respond to them using best practice options. High rates of HHC growth and persistently high staff turnover in the HHC industry underscore the importance for HHW health and safety training methods that are effective and efficient.

The home healthcare virtual simulation training system (HH-VSTS) was developed to train HHWs to detect and respond to hazards they encounter in patient homes. Hazards included in the HH-VSTS were based on review of the scientific literature and focus group discussions with HHW (Darragh et al., 2016; Polivka et al., 2015). Views of the HH-VSTS opening screen, the living room, and bathroom of a virtually simulated patient home are shown in Figure 1. The HHWs search for hazards in the HH-VSTS training modules that correspond to three general hazard types: (1) electric, fire, and burn, (2) slip, trip, and lift, and (3) environmental. Once trainees select an item (by clicking on it) in the virtual home, they are asked to indicate whether or not the item (e.g., throw rug) 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 the hazard. The purpose of the descriptive analysis presented in this article was to evaluate the accuracy of hazard detection in the three training modules within the HH-VSTS.

Methods

Participants.

The reported analysis includes data from 49 participants (45 females and 4 males) who met the following inclusion criteria: an HHW (nurse, occupational therapy [OT], physical therapy [PT], home healthcare aide) whose primary occupation is in HHC, or a student enrolled in a healthcare profession program (nursing, OT, PT). Exclusion criteria were susceptibility to motion sickness, under the age of 18 years, and non-English speaking. The resulting sample ranged in age from 19 to 73 years (mean = 39 years). The 31 professional participants included 26 home healthcare aides/homemakers, 2 licensed practical nurses, and 3 people who had administrative responsibilities. The experience in HHC for the professional component of the sample ranged between 1 and 33 years (mean = 13 years). The 18 student participants included 16 people who were in a registered nursing program and 2 people who were in an OT program.

Participants were recruited through local HHC agencies, healthcare professions educational programs, and word of mouth. All participants were screened for susceptibility to motion sickness via the following questions: (1) “Do you often feel sick while riding in the back seat of a car or reading in a car?” and (2) “Have you ever felt sick while in a simulator or theme park ride?” A “yes” answer to either screening question resulted in assignment to the paper-only version of the training, thus, those participants were not included in this analysis. Each participant signed an informed-consent document and received a $50 gift card for their participation. This study was approved by the institutional review boards of both universities engaged in this research.

Procedures.

Participants were trained to use the HH-VSTS by using the introductory modules (the top row of buttons in the opening screen shown in Figure 1). Training included how one should conduct a home safety walkthrough in a patient home and how to move through the virtual home to search for hazards using the computer keyboard and mouse.

Participants proceed through the training modules by identifying hazards. When the cursor is moved over a selectable item (asset) in the home, the item brightens to indicate it can be selected. Some of the selectable items are hazards (e.g., overloaded power strip) and some of the items are not hazards (e.g., picture on wall). When a participant clicks on a brightened item, a pop-up text box appears that contains the question “Is this a hazard?”. The user can choose “yes” or “no” by clicking the appropriate button in the text box. The user is immediately informed by a second text box whether the choice is correct or incorrect. If the item is not a hazard, the text box closes, and the participant can resume the search process. If the item is a hazard, another text box opens to explain why the item is a hazard, which is followed by a third text box that informs the participant about best practices for managing the particular hazard in an HHC work environment. For each training module, a unique patient scenario provides relevant context. For example, in the electric, fire, and burn module, the patient is an elderly female with chronic obstructive pulmonary disease who uses oxygen continuously and is a smoker.

This analysis focuses on the data from the three training modules and, specifically, the hazards that appear in the living room, bathroom, bedroom, kitchen, hallway, and basement of the simulated home. The outcomes of interest were the percentage of participants who clicked on and "correctly identified" hazards as hazards, the percentage of participants who clicked on and "misclassified" a hazard as a non-hazard, and the percentage of individuals who did not click on a hazard, and therein "overlooked" the hazard. Not selecting a hazard may have happened because the participant did not perceive the item to be a hazard, or they did not notice the hazardous item.

Results

Slip, Trip, and Lift Hazards

The top chart in Supplemental Digital Content 1 (available at http://links.lww.com/HHN/A100) shows the slip, trip, and lift hazards identified in the living room. The beanbag chair, clutter on the stairs, shoes on the floor, and newspapers on the floor were "correctly identified" most often. However, 21% of the participants "misclassified" the low sofa hazard, which poses a risk of injury when assisting a patient with sit-to-stand movements, making the low sofa a lifting hazard. The coffee table is an obstruction that can influence awkward postures by making it more difficult to assist patients on/off the couch; it was "misclassified" by 14% of the participants. Stacked blankets on the couch (clutter that can interfere with patient care and reduces places where an HHW can sit) were "misclassified" by 17% of the participants. An important finding is that 15%, 16%, and 12% of participants, respectively, "overlooked" (did not click on) these hazards.

In the bathroom, the highest "correctly identified" rates were for the throw rug, the puddle on the floor, and the glass shower doors. The item most likely to be "misclassified" was the towel rod, which was misclassified by 23% of participants; an additional 25% of the participants "overlooked" the towel rod. Patients might use the towel rod as support device, but it is not designed to support such loads, leading to patient falls and HHW injuries when the HHW attempts to prevent the fall or assist the patient up from the floor. The low toilet was "misclassified" as a non-hazard by 17% of participants who clicked on it; but the low toilet was "overlooked" by 18% of the participants. The lack of grab bars in a tub with a slippery surface and the lawn chair in the tub (an inappropriate substitution for a shower chair) were “overlooked” by 26% and 17% of the participants, respectively. Many of the items located on the floor near the toilet were hazards because they limit HHW access to the patient when assisting with toileting. This included the bathroom scale, magazine holder, and wastebasket, which were “overlooked” by 21%, 15%, and 10% of the participants, respectively.

When clicked on, the slip, trip, and lift hazards in the bedroom were almost always “correctly identified” as hazards. However, every hazard in the bedroom was “overlooked” by 10% or more of the participants. Most notably, the low bed height and the stacked books on the floor were “overlooked” by 19% and 15% of the participants, respectively. Similarly, few of the kitchen hazards were “misclassified.” The hazard that was “overlooked” most often, by just 7% of the participants, was the cat on the floor, which is a trip hazard. The pet food/water bowl, which was a hazard because it was in a path of travel, was “overlooked” by 13% of the participants.

In the hallway, 23% of the participants “overlooked” the bookshelf that effectively narrows the path of travel, and the same percentage “overlooked” the cat toys (trip hazards) on the floor. The rug in the hallway, a trip hazard, was “overlooked” by 21% of the participants.

The hazards in the basement were primarily slip and trip hazards. Adequate lighting is useful for detecting hazards; 62% of participants correctly identified the poor lighting (by clicking on the dim light bulb) as a hazard, 12% “misclassified” it, and 26% “overlooked” it. The stairs going down to the basement did not have a handrail in this training module. Ten percent of the participants “overlooked” this hazard. Eight to 10% of the participants also “overlooked” the laundry basket in the path of travel, clutter on the floor, or the dryer sheets on the floor (which are a slip hazard).

In summary, participants were able to correctly identify hazards most often in the living room, bedroom, and basement of the HH-VSTS. These areas displayed clutter and slip/trip hazards that may be more salient. Participants more often “overlooked” the subtle hazards in the kitchen (e.g., puddle, grease on floor) and bathroom (e.g., towel rod, slippery tub with no grab bars).

Electric, Fire, and Burn Hazards

There were several electric, fire, and burn hazards in the living room (Supplemental Digital Content 2, available at http://links.lww.com/HHN/A101). Nearly all participants clicked on and “correctly identified” the cord under the rug and the unattended candles as hazards. The overloaded multiplug receptacle was “misclassified” by two participants as a non-hazard, and two participants “overlooked” this hazard. Also “misclassified” were the tightly coiled lamp cord (8% of participants) and the nondisplayed oxygen-in-use sign (22% of participants). Hazards that were “overlooked” were a frayed electrical cord for the fan in the corner of the room (45% of participants), smoldering cigarettes in an ashtray (12% of participants), the nonworking smoke alarm (24% of participants), and an electrical outlet hanging out of the wall (37% of participants).

In the bathroom, the electric, fire, and burn hazards encountered during the training included an overloaded electrical outlet and a space heater (being in a bathroom puts it near a water source). These were “correctly identified” as hazards by nearly all those who clicked on these items. However, 12% and 16% of the participants “overlooked” the outlet and space heater, respectively. An additional hazard in the bathroom was the temperature of the hot water, which was too high. Only 58% of those who clicked on the faucet correctly identified the hot water as a hazard.

In the bedroom, the most challenging hazards to detect were oxygen tubing lying on the bed, a lava lamp, daisy-chained power strips, and an overloaded power strip (Supplemental Digital Content 2, available at http://links.lww.com/HHN/A101). Static electricity in the bedding materials in this oxygen-rich environment was a fire hazard, yet this was “misclassified” by 16% of the participants. The lava lamp, a significant heat source, was “misclassified” by 12% of participants. Nearly all participants “correctly identified” the turned-on heating pad on the bed and the smoldering cigarette in an ashtray as hazards. Between 80% and 90% of participants correctly identified a space heater near curtains and daisy-chained power strips as hazards. Likewise, the oxygen concentrator, due to its location near the space heater, was correctly identified as a hazard by 86% of the participants.

Among the electric, fire, and burn hazards in the kitchen (Supplemental Digital Content 2, available at http://links.lww.com/HHN/A101), the electrical outlet with two heat-producing appliances plugged in to it was “overlooked” by 20% of the participants and another 18% “misclassified” it as a non-hazard. Surprisingly, 13% of the participants who clicked on the fire extinguisher did not perceive the expired fire extinguisher to be a hazard, even though the pop-up window that asks if this is a hazard shows a close-up view of the status gauge. The most salient hazards in the kitchen, the stove burner left on, a space heater near a pile of newspapers, and a grocery bag on the stove, were correctly identified by 90% or more of the participants.

There were also two hazards in the hallway closet, a light bulb that hangs close to linens on a high shelf and an oxygen tank stored on the floor in the closet. More than a third of the participants “overlooked” these hazards. Although nearly all who clicked on the light bulb correctly identified it as a hazard, 18% of the participants “misclassified” this hazard by not realizing that storing an oxygen tank in an enclosed area is a hazard. In the basement, there was only one fire hazard: excessive lint in the clothes dryer. Only 70% of the participants clicked on the dryer. Nearly all of those who did so “correctly identified” the lint as a hazard.

In summary, most participants were able to correctly identify electric, fire, and burn hazards in the HH-VSTS living room such as an electric cord under a rug, unattended candles, lit cigarettes, overloaded outlets, stove burners/heating pads/space heaters left on, and a power cord near a water source. Participants “misclassified” several of the more subtle hazards in the virtual home (e.g., nondisplayed oxygen sign; two heating appliances plugged into same outlet).

Environmental Hazards

In the living room, there were eight environmental hazards. Nearly all participants “correctly identified” the stains on the sofa and on the floor (Supplemental Digital Content 3, available at http://links.lww.com/HHN/A102), as well as the clutter on the couch. Seven percent of those clicking on the coffee table “misclassified” the dust to be a non-hazard. “Dust bunnies,” when clicked on, were correctly identified as a hazard. However, 22% of the participants “overlooked” this hazard that was located on the floor in front of the love seat. Two other hazards that were often “overlooked” were the loud TV and the very high room temperature. In the HH-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. However, nearly everyone who clicked on the thermostat correctly recognized the hazard, whereas nearly 16% of those clicking on the TV did not correctly identify the noise hazard.

The most difficult environmental hazards to detect in the bathroom were the plug-in air freshener (“overlooked” by 27% of participants) and the empty soap dispenser. The latter was “overlooked” by 16% of the participants and was “misclassified” as a non-hazard by 9% of the participants. Although 89% of the participants correctly identified the moldy shower curtain as a hazard, only 76% correctly identified the moldy tub as such. To see the latter, participants needed to open the shower curtain (by clicking on it) and then look in the tub. Twenty-two percent of the participants “overlooked” this item. Approximately 90% of the participants clicked on the open bottle of drain cleaner located on the counter next to the sink and the soiled adult diapers in the trash. All that did so “correctly identified” these items as non-hazards.

In the HH-VSTS, there were five environmental hazards in the bedroom. The dirty bedside commode and used dog/puppy pad were correctly identified by 86% and 89% of the participants, respectively. Eighty-two percent of the participants correctly identified the wastebasket containing discarded sharps and bedbug stains on the bedding as a hazard. Only 69% of the participants clicked on the large television set on top of a narrow dresser as a potential hazard, which could be unstable and fall. Of those who did, 14% “misclassified” this as a hazard.

In the kitchen, over 90% of the participants “correctly identified” the spoiled food, bug spray on the counter, roach feces, the dead mouse in the mousetrap, and the needles sticking out of a trash bag as hazards (Supplemental Digital Content 3, available at http://links.lww.com/HHN/A102). The lack of a carbon monoxide monitor in a house with a gas stove was “misclassified” as a non-hazard by approximately 10% of those who clicked on the stove. Fourteen percent of the participants “overlooked” the unlabeled squeeze bottle, however of those who did select it, only one participant did not think it was a hazard. The broken glass in the sink was “correctly identified” as a hazard by all who clicked on it, but 18% of the participants “overlooked” this item. The lowest detection rate was with the overloaded cupboards from which there were falling objects if the door was opened. Forty-one percent of the participants “overlooked” the hazard posed by stored objects that fell from an overhead cupboard when the cabinet door was opened. These participants did not open that cupboard door when exploring the kitchen.

Other environmental hazards in the home included a mousetrap, an uncovered jar of paint thinner, an uncapped bleach bottle, and poor lighting in the basement. These hazards were only clicked on by 73% to 86% of participants. The open bleach bottle and the poor lighting were both “misclassified” as non-hazards by 7% of participants. Poor lighting was also a problem in the home’s hallway, but it was only “correctly 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 “overlooked” by 30% of the participants.

In summary, multiple environmental hazards were located in the living room and kitchen of the HH-VSTS and most participants were able to correctly identify these items as hazards (e.g., stains on sofa and carpet; spoiled food, dead mouse, needles). Items “overlooked” in this module by over 25% of the participants included the thermostat set too high, an air freshener in the bathroom, unstable objects (TV, cans in kitchen cupboard), and poor lighting in the basement.

Discussion

The three training modules in the HH-VSTS were designed to provide training on three common types of hazards HHWs can expect to encounter in patient homes. Overall, participants found and correctly identified many of the most salient hazards. However, many of the less salient hazards were “overlooked” or were incorrectly classified as non-hazards (“misclassified”) when they were selected. This finding is consistent with prior research, for example, Leonard et al. (1997) reported their college student participants had limited knowledge of electrical hazards in the home. Thus, it may not be surprising that many participants, many of which were college students, found it difficult to find and identify some of the electrical hazards in that particular training. If someone does not recognize something as a potential hazard, it may be difficult for him/her to identify such hazards in the HH-VSTS. Alternatively, even if participants have some general knowledge about home hazards, finding the hazards in a particular home may still be challenging based on the relative salience of the hazards. More salient hazards that stand out in a patient’s home may be more likely to be correctly identified, aside from extent of knowledge about home hazards. Training activities can significantly impact the ability to correctly identify hazards. For example, exposures identified in one-on-one interviews and subsequently ranked into perceived level of risk categories using sorting cards by Suarez et al. (2017), HHWs indicate an increased awareness and exposure to ergonomic hazards, and selected biological, chemical, and environmental hazards. Similarly, in a study by Agbonifo et al. (2017), HHWs who participated in interviews were asked to recall the frequency of exposure to several different types of tasks that could expose them to hazards in their work process. Electrical and fire hazards were not identified by their participants, potentially because these types of hazards occur less frequently, and, given the difficulty our participants had in finding some of these types of hazards, they may not have been recognized by the participants in these prior studies. Approximately one third of the nursing student participants in the Polivka and Wills’s (2014) study did not recognize cleaning products as a significant environmental hazard. This suggests that routine experience with common household hazards such as cleaning products may also play a part as many participants casually reported that some of the hazards identified by the HH-VSTS exist within their patient’s homes. As Gershon et al.

(2012) reported in their paper describing the development of a household safety checklist: "…most of the participating HHWs had typically been in their patients' homes many times," the tool (checklist) provided the structure for actually "seeing" the hazards, which, as one HHW stated, "were there all along, right under my nose" (p. 56).

Most participants did well within the slip, trip, and lift module at detecting the clutter within the spaces that could interfere with movement or patient handling tasks. The extent of the clutter in the virtual simulated living room, kitchen, and bedroom could be described as a "2" on the Clutter Image Rating Tool (Frost et al., 2008) for all three rooms, supporting that the extent of clutter in the VSTS was relatively modest compared with the more extreme examples on this visual scale. Extensive amounts of clutter are often seen by HHWs in patient homes in association with impaired patient ability to maintain the home environment, including removal of clutter. Other health issues can also contribute to excessive clutter. Cath et al. (2017) report the prevalence of hoarding disorders increases with age and is independent of gender. In their sample from the Netherlands, approximately 12% of the population over 70 years had a hoarding disorder, which would most likely translate to significant clutter within the homes. Clutter appears to be difficult for hoarding individuals to recognize in their own homes (Frost et al.), so recognition of the problem by an HHW could be beneficial to the worker's safety as well as a beginning to assist a patient with such a problem.

Some of the most challenging hazards to detect were the hazards set up by the absence of items, for example, a lack of grab bars in the bathroom and shower (meaning patients may be using towel rods for support), the absence of a handrail on the basement stairs, or the nonworking smoke detector. Other hazards were context-dependent, for example, the unattended burning candles were in an environment that was oxygen-rich given the patient's need for supplemental oxygen, and there was a cat in the house that could knock over the candle. Therefore, one must consider more than just the item itself when making decisions regarding the presence and potential severity of a hazard. This may be why some of the hazards in the HH-VSTS appeared to be overlooked. This is clearly a limitation of the current version of the HH-VSTS, for if a participant does not select a hazard, he/she will not see the training materials related to the specific hazard, including the explanation as to why the item is a hazard and suggested remediation strategies. Based on this finding, all three training modules in the HH-VSTS were subsequently modified to include hints that will guide the users toward unfound hazards in each room within each module.

In summary, this analysis found most of the hazards within the HH-VSTS training modules were found by the study participants. Although this could also potentially translate to the ability to detect hazards in the real-world environments, this still needs to be determined. Importantly, this analysis also indicated which hazards may be overlooked by HH-VSTS users. This suggests potential improvements to the HH-VSTS wherein the saliency of lesser known or hard to find hazards is increased or, alternatively, hints are provided to guide the user toward hazards without inflating the saliency beyond what could be expected in real-world settings. Anecdotally, most participants communicated that they enjoyed training with the HH-VSTS. Even though there were moments of frustration when hazards could not be found, most people recognized the usefulness and usability of the training program (Polivka et al., 2019), therein recognizing that the HH-VSTS could enhance their safety. Organizations interested in using the HH-VSTS as part of their safety program can download it at the following website: http://homehealthcaresafety.osu.edu/. As Macdonald et al. (2017) and Sherman et al. (2008) conclude, personal safety is an important factor affecting overall job satisfaction of HHWs and their desire to continue in their chosen profession. Given the growing need for HHWs, retention and attracting new individuals to this field will be essential in future years, and as the HHW populations grow, so will the need for effective and efficient methods of training.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

The HH-VSTS opening screen and views of the living room in the slip, trip, and lift module and the bathroom environmental module.