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A Test of Social Cognitive Theory to Increase Hearing Protection Use in Swine Buildings

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Abstract

Farming ranks among the top occupations for which workers are at risk for noise-induced hearing loss (NIHL), an irreversible yet preventable condition. Hearing Protection Devices (HPDs) (i.e., earmuffs and ear plugs) are effective at preventing exposure to noise; however, few farmers report consistent use. The purpose of this study was to test an intervention based on Social Cognitive Theory with interactive smartphone technology to increase the use of HPDs among swine facility workers. A pilot, quasi-experimental study was implemented among 72 younger adult swine workers. Participants were randomly assigned to one of three groups. Group 1 received HPDs (e.g., earmuffs and ear plugs). Group 2 received the same HPDs as Group 1 and was also instructed to use a smartphone application to track their use of hearing protection for 60 days. Group 3 received the HPDs and instructions on using a smartphone app for tracking the use of hearing protection and setting daily goals for hearing protection use. Use of hearing protection was assessed via an online survey prior to the intervention (i.e., “baseline”), immediately after the post-intervention, and at a 3-month follow-up.

Compared to baseline use, all three groups reported increased use of hearing protection immediately post-intervention. However, this increase was not maintained at a 3-month follow-up for two of the study groups. Group 3 (HPD, tracking, and goal-setting app) showed the greatest increase in the use of HPDs from baseline to immediate post-intervention; however, Group 1 (HPD only) showed the greatest sustained increase from baseline to the 3-month follow-up. Modifying the environment by supplying HPDs was effective in increasing HPD use among swine facility workers. Improving access to hearing protection devices alone may lead to sustained changes in behavior.

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Keywords

Agricultural safety and health; Hearing protection; Noise-induced hearing loss; Young adult workers

Agricultural workers are exposed to hazardous levels of noise, and farming ranks among the occupations with the highest rate of noise-induced hearing loss (NIHL) (Ehlers and Graydon, 2011). Among agricultural environments, work inside swine buildings has been identified as a source of hazardous noise (Achutan and Tubbs, 2007; Humann et al., 2005). Tasks-based assessments of swine facilities have consistently documented noise levels that exceed the National Institute for Occupational Safety and Health's Recommended Exposure Limits for common production activities, including power-washing, snout snaring, and ear clipping (Achutan and Tubbs, 2007; Humann et al., 2005). Across major pork-producing states in the Midwest, the design, function, and environmental conditions of swine buildings are very similar, as are the day-to-day tasks required to care for the livestock (i.e., cleaning, feeding, and farrowing). Therefore, human exposure to noise across swine facilities in the Midwest is expected to be similar and ubiquitous.

NIHL is an irreversible yet preventable impairment. Hearing protection devices (HPDs) (i.e., earmuffs, ear plugs) are effective at reducing personal exposure to noise (Smith et al., 2008). However, in prior studies, only a small proportion of the agricultural population reported using hearing protection (Carpenter et al., 2002; Cramer et al., 2017). In a survey of young adult agricultural workers in the Midwest, over 60% reported working in a swine facility. However, only 16% of young adults (ages 18 to 24) reported *often* or *always* wearing HPDs when working in a swine building (Rudolphi et al., 2015).

Interventions to increase the use of hearing protection among agricultural workers are few in number and (i) have mostly targeted either children or older adult farmers (Berg et al., 2009; Gates and Jones, 2007; Khan et al., 2018; Knobloch and Broste, 1998; Sherman and Azulay Chertok, 2014; Smith et al., 2008), (ii) have lacked a theoretical foundation, and (iii) were not well-evaluated (Witte et al., 1992). Given adolescents' and younger adults' regular exposure to hazardous noise, participation in swine facility work, and frequent reporting of symptoms of NIHL (Rudolphi et al., 2015), rigorously designed interventions based on behavioral theory should be developed and evaluated (Kreuter et al., 1999; Kreuter and Wray, 2003; Witte et al., 1992).

Here, we report on the results of a quasi-experimental hearing conservation intervention based on Social Cognitive Theory (SCT) that employed smartphone technology to increase the use of HPDs among adolescent and young adult swine facility workers. Specifically, we implemented and tested the effect of three major constructs from the SCT: environmental conditions, personal cognitive factors, and behavioral factors on HPD use (Bandura, 1998, 2004). The theory has been used as the foundation of other interventions that have successfully modified health behaviors (Rogers et al., 2005; Shamizadeh et al., 2019).

Social Cognitive Theory

Bandura's Social Cognitive Theory suggests that learning occurs in a social context, with reciprocal and engaging interactions between an individual, the environment, and behavior. The theory delineates supposed mediators of behavior and behavior change. Within the context of Social Cognitive Theory (SCT), *environmental conditions* are the barriers or facilitators that affect a behavior (see table 1). For example, a limited access to HPDs has been identified as a barrier to their use, suggesting that HPD access is an environmental condition that affects safety behavior (McCullagh, 2011; McCullagh et al., 2010).

The second construct of SCT, *personal cognitive factors*, suggests that for behavioral change to occur, an individual must develop "self-regulatory skills" (Bandura, 1998). Self-regulatory skills promote an individual's ability to regulate their own behavior, often through reflection and self-awareness, and require that they pay close attention to their behaviors and habits (Bandura, 1998). Behavioral tracking, such as logging behaviors or keeping a diary, is an effective tool for developing self-regulatory skills (Stajkovic and Luthans, 1998). Smartphone apps allow for efficient and interactive behavioral tracking and are an appealing intervention platform among young adults (Klasnja and Pratt, 2012). The use of smartphone apps to foster self-regulatory skills has been successful in modifying behaviors related to weight loss and weight management (Carter et al., 2013a, 2014b; Dennison et al., 2013; Patrick et al., 2014), smoking cessation (Buller et al., 2014), and cancer screening (Lee et al., 2014).

The final construct of the SCT, *behavioral factors*, are actions that enhance the adoption of a behavior and include personal intentions or goal setting. Goal setting has been found to promote behavioral change and, like self-regulatory skills, can be facilitated with smartphone technology (Bandura, 1998).

The objectives of this pilot study were to compare before and after changes in reported HPD use among swine facility workers who participated in an intervention designed around the constructs of Social Cognitive Theory.

Materials and Methods

Research Design

A quasi-experimental study was implemented to evaluate the effectiveness of the SCT-based intervention designed to increase the use of HPDs among 72 swine facility workers (details of selection procedure described in recruitment). Assessments of HPD use were made prior to participant assignment to an intervention group ("baseline survey"), again after the 60-day intervention period ("post-intervention survey"), and three months after the post-intervention survey ("follow-up survey"). The research study was approved by the Institutional Review Board at the University of Iowa.

Participant Recruitment & Randomization

Recruitment—Participants were recruited from various agricultural organizations that engage adolescents and young adults in the US Midwest. The study was advertised to

the producer-members of the Iowa Pork Producers trade organization with a notice in their bi-weekly online newsletter. The Iowa Farm Bureau's Young Farmer Program, which provides programs and resources to farmers between the ages of 18 and 35, provided study information to potential participants via its social media outlets and allowed recruitment at the annual winter conference. Iowa high school agricultural education teachers were provided with a written description of the study via a statewide weekly newsletter and asked to provide it to interested students aged 16 and older.

Individuals interested in participating were directed to an online screening questionnaire. To participate, individuals must have met the following inclusion criteria: (1) be between the ages of 16 and 35; (2) report entering a swine building at least once per day; (3) report using HPDs less than 50% of the time spent in a swine building; (4) work for a facility without an active hearing conservation program; and (5) own and use a smartphone. Participants were compensated \$150 for completing all phases of the project.

Randomization—Random numbers, generated using Excel's RANDBETWEEN function, were used to assign participants to intervention groups. Participants who met the study criteria were randomly assigned to one of three intervention groups.

Intervention Groups

Group 1—Group 1 addressed the environmental conditions of SCT. These individuals received an HPD kit (described below), recognizing limited HPD access may be an environmental barrier to their use (McCullagh et al., 2010).

Group 2—Group 2 addressed the environmental conditions *and* personal cognitive factors of SCT. These participants received the same materials as Group 1 *and* instructions to use a smartphone app to track their HPD use when inside swine buildings. Printed instructions included how to download the app, how to customize the tracking activities, and how to track activities. Participants were encouraged to track activities daily.

Group 3—Group 3 addressed environmental conditions, personal cognitive factors, *and* behavioral factors of SCT. These participants received the same materials and instructions as Group 2 *and* instructions to set a daily goal for HPD use. Participants were encouraged to set a goal of using HPDs every time they completed a task in a swine facility. They were, however, reminded to make a goal that was realistic for them.

Procedures and Materials

Hearing Protection Device Kit—All participants were mailed an HPD kit. The kit included two types of hearing protection equipment (120 pairs of disposable ear plugs and one pair of over-the-ear muffs), a brochure produced by the Great Plains Center for Agricultural Health on NIHL among farmers (GPCAH, 2017), and an introductory letter from the PI. Kits sent to participants in groups 2 and 3 included printed directions for downloading and using the smartphone app (described later).

Smartphone App – Habitbull—The smartphone app, *Habitbull*, was selected to track HPD use because it allows users to customize the activities that they want to track, sends daily reminders to participants to track their behaviors, and allows participants to set daily goals (Group 3). It is also chosen since it is available free of charge for both the Android and iPhone operating systems.

Participants were instructed to download *Habitbull* onto their smartphones and to track the total number of times they entered a swine building each day and the total number of times they wore HPDs when entering swine buildings each day (fig. 1).

HPD Use Tracking in Habitbull—Participants in Groups 2 and 3 were instructed to track their HPD use in *Habitbull* each day for 60 days. For each participant, the behavior tracking period began after receipt of study materials and setting up of the *Habitbull* app. The tracking period was approximately June 15 to August 15. Entries logged into *Habitbull* were not sent or shared with the project team.

Participants tracked the number of entries into a swine building each day (for example, if someone entered a swine building 4 times during the day, they would record 4). Participants also tracked the number of times they wore HPDs when they entered a swine building each day (for example, if someone wore HPDs 3 times when entering a swine building during the day, they would record 3) (fig. 1).

Participants in Group 3 were also instructed to set a daily goal for HPD use in the *Habitbull* app based on the average number of times they reported entering a swine building. They were encouraged to set a goal of wearing hearing protection devices more often than their reported use at baseline.

Participants tracked daily HPD use with the app by *entries* into swine buildings and the number of entries HPDs were used, whereas participants reported HPD use during the three days prior to survey completion by *tasks* on the baseline, post-intervention, and follow-up surveys (i.e., feeding, walking pens, farrowing, etc.). Different metrics (*entries vs tasks*) were unavoidable due to the daily variation in tasks performed and the capabilities of the smartphone app. The no-cost version of the app did not allow for the 11 different tasks (feeding, walking pens, farrowing, etc.) to be listed and reported on.

Data Collection Study

Surveys Baseline Survey—Prior to group assignment, all participants were asked to complete an online survey to collect information about participant gender, age, race, marital status, education, hours per week in a swine building, hours per week performing farm/agricultural work, and hours per week performing non-farm/agricultural work. The survey also collected baseline information about the use of HPD when inside a swine building and the total number of swine activities so that a *proportion of HPD use* variable could be calculated (described in Data Analysis). A list of common swine-related tasks was presented in matrix form to each participant in the online survey. Swine tasks included (1) feeding pigs, (2) walking pens, (3) loading/unloading, (4) inseminating, (5) processing piglets, (6) cleaning buildings, (7) inoculating swine, (8) heat checking, (9) ultrasound monitoring, (10)

moving pigs within the building and (11) other. Participants were asked to report the number of times they completed each task during the previous three working days (0, 1, 2, etc.) and the number of times they wore hearing protection when completing the task (0, 1, 2, etc.).

Post-Intervention Survey—After sixty days, an online post-intervention survey was administered to ascertain the current *proportion of HPD use*. The *Proportion of HPD use* was collected using the same method as the same post-intervention as it was a baseline. Participants in Groups 2 and 3 were also asked about their use of the smartphone app (described below). The post-intervention survey was sent to the email address on record, and participants were asked about their HPD use in the past three working days. Two reminder emails were sent, five and ten days after the original email was sent.

Follow-up Survey—Three months after completion of the post-intervention survey, an online follow-up survey was administered to ascertain the *proportion of HPD use*. The *Proportion of HPD use* was collected the same at follow-up as it was at baseline and post-intervention. The follow-up survey was sent to the email address on record, and participants were asked about their HPD use in the past three working days. Two reminder emails were sent, five and ten days after the original email was sent.

Data Analysis

Analyses were performed using SAS version 9.4 (SAS Institute; Cary, NC). Frequency distributions and means were used to summarize the demographic characteristics of the study sample.

A *proportion of HPD use* was calculated for each participant at baseline, post-intervention, and follow-up. The *proportion of HPD use* was calculated by dividing the number of times participants reported wearing HPD when completing the 11 swine tasks (listed above) in the previous three working days by the total number of times they completed tasks during the previous three working days. We multiplied the *proportion of use* by 100 in order to report the *proportion of HPD use* as a percent at baseline, immediate post-intervention, and at follow-up.

HPD use at baseline, post-intervention, and 3-month follow-up was not normally distributed. The changes in reported HPD use for each participant are as follows: (1) the difference in reported HPD use from baseline to post-intervention was calculated by subtracting reported use at baseline from reported use at post-intervention; (2) the difference in reported HPD use from post-intervention to follow-up was calculated by subtracting reported use at post-intervention from reported use at follow-up; and (3) the difference in reported HPD use from baseline to follow-up was calculated by subtracting reported use at baseline from reported use at follow-up. Within each of the three groups, mean changes in reported HPD use from baseline to post-intervention and from baseline to follow-up were compared using the Wilcoxon Signed-Rank test with available matched pairs only.

Results and Discussion

Results

Recruitment efforts resulted in the completion of the screening questionnaire by 119 individuals, 40 of whom did not meet study inclusion criteria. The remaining 79 individuals were then invited to complete the baseline survey. Seventy-two completed the baseline survey and were randomized into study groups ($n = 24$ per group) (table 2).

The mean age of participants at baseline was 24.8 ($SD = 5.8$) years old. Over 75% of participants were male, and 98.6% were white. Participants were primarily owner-operators (36.0%), full-time workers (41.7%), or part-time workers (16.7%). Participants reported spending an average of 25.6 ($SD = 14.6$) hours per week in a swine building (table 2). The mean *proportion of HPD use* at baseline for all three groups was 16.9% ($SD = 27.6\%$). However, use at baseline varied by group (table 3). On the post-intervention survey, Group 1 participants reported a 32.0% increase in HPD use; Group 2 participants reported a 42.3% increase in HPD use; and Group 3 participants reported a 47.1% increase in HPD use compared to their respective reported use at baseline (table 3). At 3-month follow-up, Group 1 participants reported a 4.0% increase in the *proportion of HPD use*, while Group 2 and Group 3 reported a 26.5% decrease and a 20% decrease, respectively, compared to their reported *proportion of HPD use* at baseline (table 3).

Statistical testing with the Wilcoxon signed-rank test was performed with available matched pairs only (which accounted for the small differences in results between tables 3 and 4). Statistically significant increases in mean reported HPD use from baseline to post-intervention were observed among all three groups (table 4) from baseline to post-intervention. While groups 2 and 3 reported decreases in HPD use from post-intervention to 3-month follow-up, increases in HPD use from baseline to 3-month follow-up remained significant.

Among participants in Group 2 and Group 3, 68.3% reported using Habitbull at least five times a week to track their entries into swine buildings and HPD use at entry during the 60-day behavioral tracking period (table 5).

Discussion

We observed an increase in the reported proportion of HPD use among participants of all three groups at immediate post-intervention, with the greatest increase observed among Group 3 (47.1%). However, at the time of the 3-month post-intervention survey, we observed a decrease in reported HPD use among Group 2 and Group 3. Only Group 1 had maintained and slightly increased (4.0%) reported HPD use from immediate post-intervention to 3-month follow-up. However, it is important to acknowledge that at 3-month follow-up, all three groups reported a statistically significant increased proportion of HPD use when compared to baseline.

Changes in the reported *proportion of HPD use* among the three groups are similar to those reported among participants who had been assigned interventions designed to increase the

use of HPDs among agricultural youth (Knobloch and Broste, 1998) and adults (McCullagh, 2011; McCullagh et al., 2016). The results observed in these groups from baseline to immediate post-intervention were consistent with our hypothesis that the group with the greatest engagement with the intervention would experience the greatest increase in reported HPD use. Study groups received varying levels of direction for the intervention as guided by Social Cognitive Theory.

Group 1 only received a box of HPDs, acknowledging access to HPDs may be a barrier to using the technology. Group 1 participants reported an increased *proportion of HPD use* from baseline to immediate post-intervention and a small increase from immediate post-intervention to 3-month follow-up, suggesting that simply providing access to HPDs increases use. This supports previous findings that found access to HPDs may be a barrier to use (McCullagh et al., 2010). When considering resources, simply providing HPDs at little cost to farmers may be more beneficial and efficient than developing an intervention and less burdensome.

Group 2 also received a box of HPDs but also received directions to log their daily HPD use in *Habitbull*, the smartphone app, which addresses two constructs of the Social Cognitive Theory: *environmental factors* and *personal cognitive factors*. There was a reported 15.1% increase in HPD use from baseline to 3-month post-intervention but a 24% decrease from post-intervention to 3-month follow-up. These results are similar to those of Group 3. Group 3's intervention addressed three constructs of the SCT: *environmental factors*, *personal cognitive factors*, and *behavioral factors*, and we observed changes in behaviors consistent with those predicted by the theory. By design, Group 3 participants also experienced a high level of engagement with the *Habitbull* app, receiving feedback on whether they had accomplished their daily goal for HPD use.

We speculate the decrease in reported HPD use by Groups 2 and 3 may be due to very few members of these intervention groups ($n = 2$) continuing to use the smartphone app to track HDP use after the 60-day intervention period ended. Push notifications or reminders to continue using the app after the initial intervention is over may help maintain app use. Self-managed interventions often benefit from “booster” sessions or contacts with participants to uphold the initial beneficial effect, like HPD use (Newman et al., 2004), which would be something to consider in future interventions.

Social Cognitive Theory explains how individual experiences, actions, and environmental factors influence individual health behaviors. Behavior change is achieved through self-efficacy, observational learning, and reinforcements through social support (Bandura, 1998, 2004). The HPD intervention included components from the three major tenants of SCT: cognitive factors, environmental influences, and behavioral factors. A smartphone app was used to develop self-efficacy and self-control (regulating and monitoring behaviors), and among some participants, specifically group 3, the app offered reinforcement if a goal was met. Additionally, environmental factors, such as barriers to HPDs, were addressed by sending all participants a box of HPDs.

However, there are some components of SCT that the HPD intervention failed to address and might explain the regression observed in HPD use among some participants. Observational learning, a type of learning that occurs by observing others, is a component of environmental influences in SCT (Glanz et al., 2015). Similarly, social support is also a component of SCT that was not specifically addressed in the HPD intervention. Social support includes the encouragement or support an individual receives from their social network (Glanz and Bishop, 2010; Glanz et al., 2015). When we consider that the target audience for this intervention was young adults who might be eager to fit in or receive praise from peers, observational learning and social support could have been influential on behavior change. However, given the variability in employment on swine farms in the Mid-west, considerations for social support and/or observational learning may be limited. This is, however, something to consider when designing future interventions. While we hypothesize behavior change may be enhanced or increased by including these specific components of SCT, the evidence for including all components of SCT is mixed. A meta-analysis of SCT interventions to improve physical activity and diet behaviors in cancer survivors reported significant improvements. However, no SCT constructs were associated with the interventions (Stacey et al., 2015). Maintenance, or sustained behavior change, is also not acknowledged in SCT, though it is a central tenant in some behavioral change theories (Glanz et al., 2015). However, research exploring the impact of boosters, whether it be educational information or additional HPD supplies, could inform efforts to sustain or maintain behavioral change among young adult swine facility workers. We used the smartphone app *Habitbull* to address the personal cognitive and behavioral constructs of the SCT. We see promise in using mobile digital technology to assist with changing safety behaviors. Among the participants assigned to an intervention that included interaction with a smartphone app in our study (n = 48), almost 70% reported using the app five or more days a week, suggesting this is an accepted technology among members of the population. Smartphone apps have been used for health intervention to encourage weight loss (Carter et al., 2013a,b; Dennison et al., 2013; Patrick et al., 2014), increase physical activity (Buckingham et al., 2019), and smoking cessation (Buller et al., 2014) with success. Our results suggest the technology is also appropriate for rural populations and safety-related behaviors, but not necessary to promote behavioral change. A future line of inquiry is whether smartphone apps are acceptable and useful across the age spectrum of workers or if these technologies appeal to certain demographics. As noted earlier, the mean age of Group 3 was younger than that of Groups 1 and 2, which may have contributed to interest and willingness to use the app and ultimately encouraged behavior change towards HPD use.

Strengths and Limitations

There are a number of notable strengths in this pilot intervention. This is among the first interventions to use smartphone technology to increase safety behaviors among an agricultural population. Another strength of the intervention is its foundation in Social Cognitive Theory (SCT). Importantly, SCT does not address the maintenance of behavior change. This may explain why we observed an increase in the *proportion of HPD use* at the immediate post-intervention, but it was not maintained at 3-month follow-up.

There are additional limitations to our pilot. As we expected due to the demographics of the workforce, a large proportion of the study sample was male (78%) and white, which may limit the generalizability of our results. While intervention group assignment was random, selection into the study was not. Individuals motivated to increase the use of HPDs may have participated in the study, limiting its generalizability to all swine building workers. There were also notable differences between groups despite randomization. Group 3 was younger and reported more HPD use at baseline, both of which may have contributed to the results.

The use of HPDs, the primary outcome measure, relied on self-reported data, which may not have been accurate. However, direct observation was beyond the resource capabilities of the project. Participants in Groups 2 and 3, who were tracking their daily activities using the smartphone app, may have more accurately reported HPD use than Group 1 when completing the immediate post-intervention survey, resulting in differential misclassification of the outcome variable. The research team did not have access to individual app updates or logs for groups 2 or 3, which was a missed opportunity for in-depth data analysis. However, requesting data logs on the backend of the app is an area of future exploration.

All three study groups experienced varying levels of attrition. After final data collection, Group 1 had the lowest drop-out proportion (12.5%) and Group 3 had the highest (33.3%). Similar drop-out proportions have been reported in other web-based interventions (Neve et al., 2010). Group 3 participants were asked to engage with the smartphone app at a higher level than the other groups, which may have been too burdensome for participants and encouraged dropout.

Finally, changes in the reported *proportion of HPD use* should be interpreted with some caution. As hypothesized, all three groups reported an increase in reported HPD use from baseline to immediate follow-up. However, without a reference group that did not receive any intervention (control group), it is possible that changes in HPD use were the result of factors other than the intervention, such as being enrolled in a study about hearing protection device use. This is a limitation of the quasi-experimental study design. Finally, the small sample size ($n = 72$) limits the power to distinguish differences in HPD use among groups. While our results suggest a trend towards increased HPD use, a larger, randomized control trial is necessary.

Conclusions

Our study contributes to the body of knowledge supporting the application of behavioral theories into occupational safety interventions to modify behaviors. We recommend additional research testing the use of Social Cognitive Theory, as well as additional theories, to frame occupational safety and health interventions. While smartphone applications offer promise to assist in behavior change, results from our study indicate that providing hearing protection devices to participants resulted in the greatest increase in HDP use at follow-up, suggesting that modifying the environment may be more beneficial than complicated tools to aid in behavioral change. However, larger, randomized controlled studies with longer follow-up periods and more sophisticated smartphone applications could yield different

results and should be tested as methods to increase the use of HPD among agricultural populations.

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Highlights

- Almost 50% of participants reported engaging with the smartphone app *Habitbull* daily.
- Access to high-quality hearing protection devices may be enough to change behaviors towards hearing protection device use among young adults.

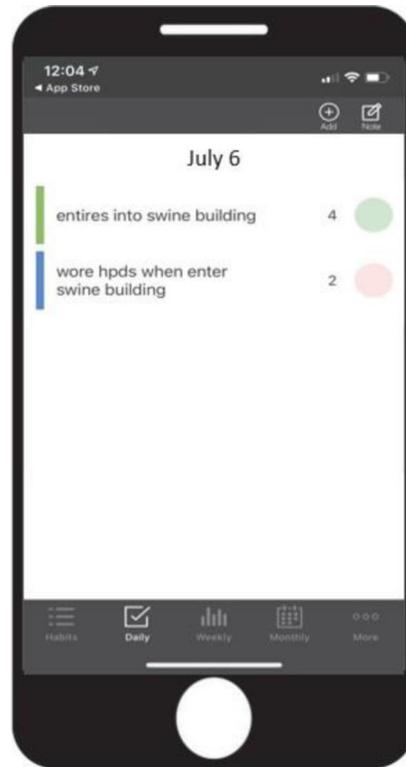


Figure 1.
Screenshot of Habitbull App during Behavioral Tracking Period.

Table 1.

Social Cognitive Theory constructs in relation to HPD intervention group.

	Social Cognitive Theory Constructs		
	Environmental conditions	Personal Cognitive Factors	Behavioral Factors
Description & Definition	Physical and social factors that serve as barriers or facilitators that permit or discourage a behavior.	The ability to self-regulate behavior, develop self-regulatory skills, and reflect on experiences	Actions that enhance the adoption of a behavior and include personal intention or goal setting.
Addressed by HPD intervention	Participants received appropriate and high quality HPDs.	Participants instructed to track their HPD use each day.	Participants instructed to set a daily goal for HPD use.
Intervention Groups	Group 1, Group 2, Group 3	Group 2, Group 3	Group 3

Table 2.

Demographic characteristics of study sample at baseline by study group.

Demographic	Characteristics	Group 1 (N=24)	Group 2 (N=24)	Group 3 (N=24)	Total (N=72)
Gender	Male	19 (79.2%)	21 (87.5%)	16 (66.7%)	56 (77.8%)
	Female	5 (20.8%)	3 (12.5%)	8 (33.3%)	16 (22.2%)
Age (years)	Mean (SD)	25.7 (5.2)	26.2 (6.2)	22.5 (5.5)	24.8 (5.8)
Education	High school	6 (25.0%)	9 (37.5%)	11 (45.8%)	26 (36.1%)
	Some college, tech school graduate, community college graduate	6 (25.0%)	8 (33.3%)	6 (25.0%)	20 (27.8%)
	4-year degree college graduate	12 (50.0%)	7 (29.2%)	7 (29.3%)	26 (36.1%)
Marital Status	Not married	12 (50.0%)	13 (54.2%)	15 (62.5%)	40 (55.6%)
	Married	12 (50.0%)	11 (45.8%)	9 (37.5%)	32 (44.4%)
Race	White	24 (100.0%)	23 (95.8%)	24 (100.0%)	71 (98.6%)
	Other	0 (0.0%)	1 (4.2%)	0 (0.0%)	1 (1.4%)
Farm Role	Owner-operator	11 (45.8%)	11 (45.8%)	4 (16.7%)	26 (36.0%)
	Full-time hired worker	10 (41.7%)	9 (37.5%)	11 (45.8%)	30 (41.7%)
	Part-time hired worker	1 (4.2%)	2 (8.3%)	9 (37.5%)	12 (16.7%)
	Other	2 (8.3%)	2 (8.3%)	0 (0.0%)	4 (5.6%)
Cell phone type (n)	iPhone	12 (50.0%)	8 (33.3%)	15 (62.5%)	56 (77.8%)
	Android	12 (50.0%)	16 (66.7%)	9 (37.5%)	16 (22.2%)
Hours/week in swine building at baseline	Mean (SD)	20.0 (12.2)	24.0 (13.6)	29.7 (6.7)	25.6 (14.6)
Hours/week in other agriculture	Mean (SD)	45.7 (22.6)	45.8 (8.2)	44.5 (17.6)	45.3 (19.3)
Hours/week non agriculture	Mean (SD)	7.8 (4.0)	7.8 (34.0)	8.0 (3.8)	7.8 (3.9)

Table 3.

HPD use by group status at baseline, post-intervention, and three-month follow-up.

Mean reported HPD use by each group at each time point	Group 1 Mean% (SD)	Group 2 Mean% (SD)	Group 3 Mean% (SD)
Percent of HPD events reported wearing hearing protection devices in swine buildings at baseline ^[a]	12.8 (26.2)	12.0 (20.9)	25.9 (33.3)
Percent of HPD events reported wearing hearing protection devices in swine buildings at immediate post-intervention ^[b]	44.8 (36.9)	54.3 (34.1)	73.0 (33.6)
Percent of HPD events reported wearing hearing protection devices in swine buildings at follow-up ^[c]	48.8 (42.0)	27.8 (32.0)	53.0 (43.9)

^[a]Group 1 n=24, Group 2 n=24, Group 3 n=24.

^[b]Group 1 n=21, Group 2 n=20, Group 3 n=20.

^[c]Group 1 n=21, Group 2 n=18, Group 3 n=16.

Table 4.

Mean change in reported HPD use by group from pre, post, and follow-up.

	Group 1 Mean% (SD)	Group 2 Mean% (SD)	Group 3 Mean% (SD)
Mean change in reported HPD use from baseline ^[a] to post-intervention ^[b]	31.3 (33.0) ^[f]	40.7 (35.3) ^[f]	45.6 (35.3) ^[e]
Mean change in reported HPD use from post-intervention ^[b] to follow-up ^[c]	7.8 (23.5)	- 24.2 (26.3) ^[e]	- 22.8 (41.9) ^[d]
Mean change in reported HPD use from baseline ^[a] to follow-up ^[c]	36.7 (39.2) ^[f]	15.1 (24.9) ^[d]	25.6 (48.2) ^[e]

^[a]Group 1 n=24, Group 2 n=24, Group 3 n=24.

^[b]Group 1 n=21, Group 2 n=20, Group 3 n=20.

^[c]Group 1 n=21, Group 2 n=18, Group 3 n=16.

^[d]Statistically significant difference (p <0.05) in reported HPD use when compared to HPD use at baseline for same group (Wilcoxon signed-rank test, available pairs only).

^[e]Statistically significant difference (p <0.01) in reported HPD use when compared to HPD use at baseline for same group (Wilcoxon signed-rank test, available pairs only).

^[f]Statistically significant difference (p <0.001) in reported HPD use when compared to HPD use at baseline for same group (Wilcoxon signed-rank test, available pairs only).

Table 5.

Number of days per week groups used Habitbull to track HPD use.

Frequency of participants using <i>Habitbull</i> to track activities in a week	Immediate post-intervention, <i>n</i> =41 % (<i>n</i>)
Never	12.2% (5)
Less than once a week	2.4% (1)
1–2 days a week	4.9% (2)
3–4 days a week	12.2% (5)
5–6 days a week	22.0% (9)
Everyday	46.3% (19)

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