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Self-reported respiratory health symptoms and respiratory protection behaviors of young adult hog producers in the United States

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Abstract

In this study, we evaluated self-reported respiratory symptoms during agricultural work, respiratory protection use and experience, and perceived value of receiving respirators using Gear Up for Ag Health and Safety Program™ pre- and post-surveys from 703 and 212 young adult hog producers in the United States. To our knowledge, this is one of the most extensive survey datasets with regards to self-reported respiratory symptoms and respiratory protection behaviors of collegiate-aged young adults working in U.S. livestock production. About one third (37%) of young adult hog producers stated that they have experienced cough, shortness of breath, fever, and chills after working in dusty areas on the farm. Most (76.2%) stated that they were already ‘always’ or ‘sometimes’ wearing filtering facepiece (N95-style) respirators, even before participating in an outreach program. About one third (30%) reported experience wearing a cartridge-style respirator but only 5% reported having been fit-tested for a respirator. Young adult male producers were significantly more likely to report use of both respirator types when compared to females, both before and after the program. Male producers were also more likely than females to engage in high-risk farm tasks where respirators are recommended, such as cleaning out grain bins and mixing or grinding feed. Following an educational program, males and females reported using the respirators that they received at similar rates, and 20% of overall participants purchased additional respiratory protection. The study found that young adult hog producers in post-secondary education are already wearing respirators with some frequency and at rates higher than previously reported by other agricultural workers. More research is needed to make effective task-based respirator-use recommendations and investigate some significant gender differences among young adult hog producers observed in this study.

Keywords

agriculture; gender; grain handling; livestock; occupational; outreach; respiratory health; respiratory protection; respirator; swine

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Introduction

Since the 1970s, numerous studies have examined respiratory symptoms and lung function of persons who work in swine barns, and have identified endotoxin, total dust, respirable dust, ammonia, and use of chemical cleaners or disinfectants as potential hazards (Kirkhorn and Garry, 2000; Von Essen et al., 2010; Basinas et al., 2015). The newer design of swine barns provides efficiency in ability to handle waste and distribute feed, but also means a significant number of hogs in one location and need for ventilation systems (Viegas et al., 2013; Basinas et al., 2015). Exposures to dust in pork production are common, and the tasks of moving pigs, feeding pigs, and weaning are often associated with the highest dust exposures (O'Shaughnessy et al., 2009; Von Essen et al., 2010). Both occupational tasks and the indoor air quality of the barns is highly variable and may shift with the seasons, with colder seasons associated with higher dust exposure (O'Shaughnessy et al., 2009).

In many agricultural industries, the use of respirators is key to preventing both acute respiratory illness, chronic respiratory disease, and other long-term disease. Although mandated Respiratory Protection Programs (through 29 CFR 1910.134 of the Occupational Health and Safety Administration, OSHA) have been found to be effective, many livestock production businesses in the United States (U.S.) do not require a mandated program (Doney et al., 2005). This may be due to either small numbers of employees or large numbers of family members working on the farm.

At the time of this article, a great deal of agricultural respiratory protection guidance focuses on 'general respirator use' without much on respirator use during specific tasks. This is likely because exposure assessments of hog producers have focused on the potential exceedance of full-shift exposure limits. Previous studies have found that hog producers' median exposure to total dust was 4.0 mg/m^3, with concentrations as high as 13.8 mg/m^3 and like that of poultry workers (Radon, et al., 2001). In these highly variable exposure scenarios, both filtering facepiece respirators and reusable cartridge style respirators with Assigned Protection Factors (APFs) of 10 or more would be appropriate for most tasks. The authors believe that providing vague or general guidance, such as "wear respiratory protection when working with hogs" is not likely to increase the use or appeal of respirators in an industry where they are worn voluntarily or with limited information on task-based exposure limits. In 2007 and 2020, Virginia Cooperative Extension provided a comprehensive list of agricultural tasks where the use of respirators is recommended (Hetzel, 2007; Grisso, 2020). Although not specific to the swine industry, this list included many tasks related to hog production such as handling hay and feedstuffs, working in silos or grain bins, and working around animal dander or manure. No matter the size of the operation or mandated requirements, all hog producers should be well educated about proper use and care of respirators so they can be empowered to make important decisions about protecting their health. In 2010, Von Essen et al. had stated that in compared to other agricultural industries, less is known about why hog production workers do not wear respirators more often (in particular, N95s), or what could be done to "increase their appeal." Since the time of the Von Essen article and after the COVID-19 pandemic in the U.S., arguably the availability and offerings of respirator types has changed a great deal.

The nonprofit organization, the Ag Health and Safety Alliance™ (AHSA), currently delivers an educational program called *Gear Up for Ag Health and Safety*™ (Gear Up for Ag™) to many young adult hog producers in North America. The program specifically targets young adults working in agriculture (ages 18–25 years) who are also enrolled in two- or four-year collegiate agriculture production programs. Gear Up for Ag™ emphasizes assessment of respiratory health, how to assess task-related risks, and how to select effective and comfortable respiratory protection. For many participants, this is the first respiratory health and safety education they receive. Participants receive a Health and Safety Kit, which includes educational brochures, safety checklists, 2-strap filtering facepiece respirators (also called N95s), a half mask cartridge respirator, reusable P100 cartridges, and various other personal protective equipment (PPE) types. The program is unique because it involves an interactive lecture, motion graphics, videos, in-classroom problem-solving, storytelling, and hands-on demonstration of safety equipment by professionals. The program includes resource-sharing through an eLearning platform to reduce paper waste and allow participants to access to resources after program completion. Typically, the respiratory health portion of the program takes 20 to 40 minutes and is dependent on overall program length. In a previous study, it was reported that program information is likely to spill over into agricultural communities, since more than 90% of participants report sharing the information that they learn in the program with peers, co-workers, friends, and family members (Gibbs et al, 2021).

In the last four years, AHSA has modified specific aspects of the respiratory health portion of the Gear Up for Ag™ program to address increasing trends of more female participants (particularly livestock producers). From 2018–2020, approximately 18% of program participants were female but in 2021–22, this increased to 30% (Gibbs et al, 2021; 2021-22 AHSA survey data, not published). This seems to be in line with an overall trend of female collegiate students studying agriculture while working in livestock production. In 2019, the United States Department of Agriculture (USDA) noted that the largest shares of women principal farm operators were on livestock operations—with 51% of livestock sales attributed to female-operated farms. Although females were more likely to report being involved in record-keeping and financial management, many female operators report substantial work on hog farms (USDA, 2017). Female hog producers also tend to be younger than their male counterparts with an average age of just over 50 years (USDA, 2017).

In 2017, AHSA worked to address these shifting demographics by providing a variety of smaller filtering facepiece respirator types in the Health and Safety Kit, such as the 3M 9211-N95 and Moldex 2200 N95 with and without valve. AHSA educators noticed during programs that female participants would complain about a) difficulty finding PPE (personal protective equipment) that fits, b) not having access to appropriately fitting respirators, or c) being told to wear the same PPE as their older male relatives. During respirator fittings, ASHA educators noticed that many female participants measured “small” for the 3M Half Mask Cartridge Respirator (Model 6500) according to manufacturer face size charts. This seemed in line with many studies performed in the last two decades showing that it can be more difficult—particularly for women—to obtain PPE, such as respirators that are the correct size and fit, likely due to facial anthropometric dimensions (Zhaung et al., 2007, Oestenstad et al., 2007; Zhaung et al., 2010). Overall, there was a lack of knowledge about

respirator sizing and size charts for both the 2-strap filtering facepiece respirators and half mask cartridge respirator.

The goal of this project was to evaluate a series of self-reported pre- and post-survey responses and examine gender specific differences in on-farm tasks reported, respiratory health symptoms, use of respiratory protection, and effectiveness of a respiratory health training program among young adult hog producers. Other demographics, such as age group and education type were examined, but only as potential confounding factors. All young adults in this study were participants Gear Up for Ag™ programs from 2017–2021 and were enrolled in university or community college agriculture programs at the time of the surveys. This project involves survey responses from young adults who stated they were engaged in U.S. swine production while simultaneously enrolled in college. Many of these young adults work with hogs on their collegiate farm, through farm internships, or even travel home to work on their family farm when they are not in class.

Materials and Methods

Pre- and post-survey administration

This study involved pre-survey responses from Gear Up for Ag™ program participants in the U.S. AHSA applies pre-and post-surveys evaluation of programs based on Kirkpatrick's Four-Level Training Evaluation Model (Kirkpatrick and Kirkpatrick, 2006). This Evaluation Model is commonly used for workplace safety programs involving a specific group of working participants. The pre-survey was administered two to three weeks prior to outreach program delivery, and the post-survey was administered one to three months following the program. Although all participants receive a Health and Safety Kit with appropriately sized PPE (value $12-$60 US, depending on program) they are mainly incentivized to complete the pre-survey by knowing that their PPE sizes will be correctly accounted for. Many young adult participants wanted access to PPE that fit them correctly. Participants are incentivized with a small cooler bag (value, $5 US) for completion of the post-survey. Each participant had access to one pre- and post-survey, as the Gear Up for Ag™ program is administered through the enrollment of an agricultural education course within a university or college. The COVID-19 pandemic had little effect on survey response rates since 2020 when the program was modified to continue in virtual, in-person, or combination formats. The collection of this data was not originally intended for research purposes, as the intent is to provide detailed information to customize and improve nonprofit outreach programs in an agricultural community. For example, pre-survey questions focus on 'respiratory symptoms experienced during agricultural work' and respirator use when working on the farm, but do not ask where these respiratory symptoms occurred or what task was related to the symptoms, as question responses were used to stimulate program discussion and participation.

All pre- and post-survey variables are described in Table 1. The pre-survey collects demographic information such as gender, education type (university/community college), country, age, production type, and farm tasks. The pre-survey does not collect information on U.S. citizenship status or ethnicity. In 2020, with consultation from two swine veterinarians, the tasks of administering pharmaceuticals/vaccines, transporting hogs (as

livestock) on roadways, taking care of piglets, and performing welding tasks (maintenance purposes, for example) were added to the pre-survey. Only U.S. participants who referenced involvement in hog production were included for data analysis. Additional pre-survey questions included self-reported respiratory symptoms and experiences using NIOSH-certified respirators. Photos were provided with survey questions about NIOSH-certified respirator use and respirator fit testing for clarification.

Post-survey responses were used to learn about knowledge retention and changes in safety behaviors following the program. The post-survey collects demographic information and questions about perceived value of the program and use of NIOSH-certified respirators and purchase of additional respirators following the program. During the respiratory health portion of the Gear Up for Ag™ program, all participants participate in a feedback activity focused on identifying areas or specific tasks on the farm where they are most likely to use the respiratory protection received in the Health and Safety Kit. Participants noted activities where they were "most likely to use the respirators that they received" on a Post-It® note to share with other participants on a white board. During this activity, demographic variables are not collected since the participation in the feedback is completely anonymous. These written responses were collected specifically from hog producers and electronically transposed this information into spreadsheet format. All data for this project was acquired from 2017 to 2021. The analysis of AHSA survey data was reviewed by the University of Iowa IRB and was determined to be not human subjects research (HSR) because analysis activities "are limited to the use of de-identified survey data gathered to tailor the creation and delivery of educational outreach to a specific audience."

Data analysis description

Pre- and post-survey responses were exported from *SurveyMonkey* into a CSV data file using 5 Python. R Studio© (version 1.3.1093, 2020) was used to categorize responses. Pre-survey data was used to calculate participant proportions on demographic variables and for responses related to farm tasks performed, respiratory symptoms experienced during agricultural work, previous experience using of NIOSH-certified respirators on the farm and having ever been fit tested for a respirator (see Table 1 for variable descriptions). Post-survey data was used to calculate proportions of participants who found value in receiving respiratory protection as part of an educational program, if they used the respirators after the program, and if they purchased additional respirators after the program. Although the researchers were initially interested in examining gender-specific differences in survey responses, two-proportions Z-tests were used to examine potential differences in proportions according to all recorded demographic factors including education type, age, and gender. For larger sample size comparisons ($\geq N = 6$) with binomial data, the Z-test is the preferred means for comparison of groups within a sample population (Mishra et al., 2019). For comparisons of small sample sizes ($\leq N = 5$), a more conservative chi-square test for proportions was used. A value of $p \leq 0.05$ was used to indicate a statistically significant Z-test or chi-square test result. The age category was split on the median into two age groups (18–20 yrs and 21–30 yrs). Initial results demonstrated that no differences in proportions were observed due to education type and age category. Comparative analysis was shifted to the initial aim, which was to examine potential gender differences among

survey responses. Blank answers on the surveys were categorized as 'missing' data. Since pre- and post-surveys were not matched, the researchers treated them as separate datasets and refrained from making direct comparisons between pre- and post-survey responses. Qualitative responses were categorized by an industrial hygienist, who identified "key terms" for areas of the farm or farm tasks where participants stated they were most likely to use the respirator received as part of the educational program. Proportions were calculated for the categorized qualitative responses. Demographic data was not available for qualitative responses.

Results

Demographics of young adult hog producers

Pre- and post-survey demographics of young adult Gear Up for Ag™ participants who were hog producers are shown in Table 2. Overall, 86% of participants who identified as hog producers completed the pre-survey (n=703) and 26% (n=212) completed the post-survey. Of those who completed the survey, about 73% were male and 27% were female, further validating the increasing trend of more female participants in the Gear Up for Ag™ program. Female producers were slightly more likely to complete the post-survey, but no other pre- and post- survey demographic differences were observed. Most of the young adult hog producers were in the Midwestern region (86%), and 14% were in the West or Southwest. The participants were evenly split among community college and university agricultural program enrollment, most were 18–25 years old. Most young adult hog producers (85%) reported beginning work on the farm and/or assistance with farm chores when they were younger than 8 years old (data not shown).

Gear Up for Ag™ pre- and post-survey findings

The most common farm tasks were reported in the pre-survey and are producers are described in Table 3. These include working and moving hogs (83%), unloading or loading feed/hay (70%), cleaning pens/housing (67%), feeding hogs (60%), and cleaning bins or other types of grain/feed storage (59%). Males were significantly more likely than females to report feeding hogs, cleaning out grain bins or feed storage, mixing or grinding feed, and transporting hogs on roadways. Females were significantly more likely than males to report taking care of piglets. Similar proportions of males and females reported moving hogs, unloading hay or feed, cleaning housing, and administering pharmaceuticals/vaccines.

Pre- and post-survey findings are presented in Table 4. Over a third (39.8%) of young adult hog producers stated that they had experienced respiratory symptoms while performing agricultural work, and 49.8% stated that they have never experienced respiratory symptoms. The survey did not indicate where these respiratory symptoms occurred or what task was related to the symptoms. There were no significant demographic differences in self-reported respiratory symptoms. Many participants reported that they were already wearing respirators before the program, with 76% stating that they at least "always" or "sometimes" wear filtering facepiece respirators when working in dusty areas. However, young adult female producers were more likely than male producers to report only "sometimes" or "never" wearing filtering facepiece respirators (Table 4). Female producers were more likely than

males to leave the question about use of filtering facepiece respirators blank. Almost a third (30%) of participants stated that they have had experience wearing a cartridge style respirator on the farm, although this appears to be mostly male producers. Males were much more likely than females to report experience with this respirator type (37% of males stated “yes” as compared to only 13% of females). The proportion of individuals reported having been fit tested for a respirator was 5%. Male producers were significantly more likely to report having been fit tested for a respirator when compared to females. Female producers were significantly more likely to report that they were “unsure” if they had been fit tested, even though photos of respirator fit testing were provided in the pre-survey.

Overall, the majority (79%) of young adult hog producers reported that they found value in receiving two types of respirators as part of an educational program, even before participating in the program. Young adult male producers were significantly more likely to answer “yes” (83%) as compared to female producers (67%), who were also significantly more likely to answer “unsure” (22%).

The Gear Up for Ag™ program seemed to be effective, with 43% and 41% of young adult hog producers answering that they were ‘very likely’ or ‘likely’ to wear the filtering facepiece respirator (N95) that they received in the Health and Safety Kit. In addition, 36% and 43% of young adult hog producers answering that they were ‘very likely’ or ‘likely’ to wear the reusable cartridge style respirator that they received. A higher proportion of male producers (45%) reported that they were “very likely” to wear the filtering facepiece respirator (N95) (45%) as compared to female producers (34%) (p=0.112), who indicated they were ‘somewhat likely’ (50%). A higher proportion of female producers (18%) reported they were ‘not likely’ to wear the cartridge style respirator following the program as compared to males (9%) (p = 0.066). Approximately 20% of participants went out and purchased additional respirators for themselves or someone else following the program. A higher proportion of female producers (18%) reported they were ‘not likely’ to wear the cartridge style respirator following the program as compared to males (9%) (p = 0.066). Unlike the pre-survey results, there were few statistically significant differences observed among gender in the post-survey.

Qualitative results

Participants involved in hog production reported during the Gear Up for Ag™ program that they were most likely to use their respirators while handing grain or feed, including work in grain bins (33%), while powerwashing or disinfecting (27%), when moving hogs (general) 14%, during hog loadouts specifically (10%), while sweeping inside the barn (8%), for non-specific work in farrowing barns (4%), or when checking or unclogging mechanized feeding equipment (4%).

Discussion

Young adult hog producers in post-secondary education programs are engaged in tasks where respirators are recommended, and they report using respirators at rates higher than previously reported by agricultural workers.

In this project, we observed that more than a third of young adult hog producers stated that they had experienced respiratory symptoms while working on the farm. This is comparable to what was summarized by Von Essen et al., which found that 20% to 40% of hog confinement workers experienced respiratory symptoms such as cough, wheezing, and shortness of breath (2010). Although this demonstrates that respiratory health may be a concern among this group, the current study did not examine the potential "cause" of the respiratory symptoms experienced since the survey intent was to provide information for the Gear Up for Ag™ program. Many young adult hog producers report engaging in tasks where respirators were previously recommended by Hetzel and Grisso at Virginia Cooperative Extension (2007, 2020). Although young male producers were more likely to engage in high-risk activities where respirators are "highly recommended," such as cleaning out grain bins and mixing/grinding feed, it is important to note that both male and female producers are involved in an array of tasks where respiratory protection may be recommended or even required if the specific environment has airborne levels exceeding occupational exposure limits.

Most young adult hog producers enrolled in Gear Up for Ag™ programs are already using respirators on their operations with some frequency, and this proportion reporting general use of respirators is higher than previously reported by older producers. For example, 76.2% of young adult hog producers in this study reported 'always' or 'sometimes' wearing a filtering facepiece respirator (N95) when performing agricultural work in dusty environments, and 30.4% reported that they had worn a cartridge style respirator when performing different tasks on the farm. In comparison, a respirator use survey conducted by NIOSH in 2001 found that only 5.8% of agricultural employees reported wearing a respirator in a 12-month period (NIOSH, 2003). More recent studies have found that 17–48% of agricultural producers and workers report wearing respirators (Mitchell and Schenker, 2008; Syamlal et al., 2013; Casey & Mazurek, 2017). The findings from this study do indicate that the self-reported use among respirators by these young adult producers is trending in a positive direction. More research is needed to examine the factors in this potential shift in safety culture. The recent COVID-19 pandemic heightened occupational awareness of respiratory protection, due to media coverage and the shortages of N95 respirators experienced from March 2020 to May 2021 (Gereffi, 2020). Additional research by ASHA plans to examine the impact of COVID-19 on the potential awareness of, access to, and use of NIOSH-certified respiratory protection by this young adult agricultural working population. This work is considered outside the scope of this project since it involved additional data collected in 2022.

It was unknown from the survey if these young adults considered "dusty environments" to be inside of the hog barn or housing. For example, a 2002 study among older Midwestern farmers indicated very low use of respirators inside of livestock confinement housing

(only 3% reported wearing respirators in this scenario) (Carpenter et al., 2002). The aforementioned European study found that personal exposures of hog producers were highly variable but demonstrated potential to reach recommended exposure limits for dust including bioaerosols (OSHA PEL-TWA, ACGIH TLV-TWA) (Radon, et al., 2001). The qualitative responses collected from young adult hog producers during the program indicate that they do plan to use the respirators in barn environments, such as when performing cleaning tasks, working with feed or feed equipment, moving hogs, and for general use in farrowing rooms. These responses were in line with a previous study that found that tasks like moving hogs and swine weaning resulted in potentially higher dust concentrations (O'Shaughnessy et al., 2009).

Very few young adult hog producers in post-secondary education programs reported having been previously fit tested for respirators.

Although many young adult hog producers reported wearing respirators, most of them have not been properly fit tested for a respirator or do not know what respirator fit testing is. Only 5% of young adult hog producers reported being fit tested for a respirator, and approximately 13% were 'unsure' if they were fit tested. Male producers were more likely to report having been fit tested than female producers. ASHA educators noted that in conversations with these young adults, they were likely to have been fit tested for another "off-farm" job, such as at an autobody shop or grain elevator, and that the fit test was not necessarily for the respirator they were using on their farm. Respirator fit testing should be completed prior to starting a job that requires respirator use. Fit testing is important, since it determines whether a specific respirator fits the face of the wearer.

According to the OSHA Respirator Protection Standard (OSHA, 2006), workers may use respirators voluntarily even if measured exposures are below exposure limit. In this scenario, respirator fit testing is still a good recommendation for young adults working in agriculture who want to use respirators. The qualifications for the OSHA voluntary use provision may not be applicable to many young adult producers in the *Gear Up for Ag!* program, since over half report working on their family farm (Gibbs et al., 2020). In some cases, these young adults may work on the farm but may not be considered an employee, or the farm is a small agricultural business and considered 'exempt' from OSHA regulation. The authors believe that all individuals working on the farm should be protected from respiratory hazards and that the guidelines stated in the OSHA Respirator Protection Standard, Appendix D are still applicable in these situations involving young adult producers (Appendix D to Section 1910.134 Mandatory Information for Employees Using Respirators When Not Required Under the Standard, OSHA, 2006). Due to the differences in facial anthropometric dimensions, fit testing is especially important for female producers. Most young adult producers enrolled in Gear Up for Ag™ programs are relatively new to adult-sized respirators since they are typically only 18–25 years old.

Young adult male producers were more likely to report wearing respirators and engaging in farm activities considered high risk. More research is needed to investigate why self-

reported gender differences occur and to enhance use of respiratory protection by young adult female producers.

This study revealed several significant gender differences in the reported rates of respiratory protection use. Male producers were significantly more likely to report wearing both respirator types, and more likely to report finding value in receiving respirators as part of an educational program as compared to female producers. In fact, 22% of female producers stated they were “unsure” if they found value in receiving NIOSH-certified respirators as part of an educational program, as compared to only 9% of males. It is interesting that these differences were statistically significant in the pre-survey, even though both genders self-reported experiencing respiratory symptoms while performing agricultural work. Perhaps this is because young male producers were more likely to engage in activities considered high risk, such as cleaning out grain bins and mixing/grinding feed—whereas females were more likely to engage in tasks where recommended respirator use is less clear. This includes tasks such as cleaning pens, unloading feed, or moving hogs. Our findings have highlighted significant gender differences in the types of tasks being performed on the farm. Like Von Essen et al. (2010), we assert that more research is needed on respiratory exposures during these tasks where respirators are ‘recommended.’ Additional information regarding differential exposures would help outreach professionals to better educate young producers about respirator use. Due to the variable nature of work in the pork production industry, task-specific guidance is more likely to be implemented.

More research is also needed to investigate the gender differences that were observed. Female hog producers were also slightly more likely to report ‘not likely’ to wear the cartridge style respirator or purchase an additional respirator following the Gear Up for Ag™ program. Although these differences were not statistically significant ($p \leq 0.05$), the findings still implied similar trends in reduced self-reported respirator use among young adult female producers, even after the delivery of an educational program. If gender differences are to be overcome by a broad agricultural health and safety program emphasizing respiratory health and the importance of using respiratory protection, then a) specific resources should be developed to inform on gender-specific needs, and b) multiple types and sizes of correctly sized NIOSH-certified respirators should be offered to participants, c) participants should be encouraged to partake in respirator fit testing.

The Gear Up for Ag™ program resulted in use of respiratory protection and purchase of additional respirators following the program.

The Gear Up for Ag™ program was effective in that young adult hog producers reported using the 2-strap filtering facepiece respirator and half mask cartridge respirator that they received following the program. Previous research has indicated that these two types of respirators seem to be preferred by hog producers, in contrast to other respirator preferences by poultry or grain facility workers (Popendorf et al., 2011). In addition, 20% of participants reported that they purchased an additional respirator for themselves or someone else after the program. Qualitative data collected during the program showed that many young adult hog producers planned on using the respirators in specific situations and environments.

Study limitations

Although the pre- and post-surveys were administered to the same group of young adult producers, one of the biggest limitations to this study is that individual pre- and post-survey responses were not matched. Pre- and post-survey matching is commonly done in intervention studies. The aim of this project was simply to evaluate trends of self-reported symptoms and safety behaviors and not to quantify specific changes in individual behaviors. The pre- and post-survey were treated as distinct datasets.

In the pre- and post-surveys, there was missing data (see Table 4). For example, the pre-survey questions on self-reported use of filtering facepiece and cartridge style respirators had 11% and 13% of the data missing, respectfully. 'Missing' data in Table 4 meant that the survey question response was left blank. Photos were included in the survey to clarify examples of the NIOSH-certified respiratory protection. Young adults enrolled in the Gear Up for Ag™ programs are completing these surveys primarily because they want to receive correctly sized PPE. Participation in the surveys did not require that all answers be completed. Female producers were more likely than male producers to leave survey answers blank when asked about their experiences wearing NIOSH-certified filtering facepiece respirator (pre-survey) and when asked if they purchased an additional respirator for themselves or someone else after the program (post-survey), indicating either uncertainty about the question or less desire to answer.

Unlike the pre-survey results, there were no statistically significant differences observed among gender in the post-survey. This was likely impacted by missing data for the gender question and the low post-survey response rates. There was n =26 missing for 'gender' in the post-survey. The post-survey is administered one to three months following the program. The response rate to the post survey was low (25%), but typical of agricultural working populations (Avemegah et al., 2021). Post-survey response rates were impacted if the Gear Up for Ag™ program occurred at the end of the college semester. It was difficult for AHSA educators to contact young adult participants post-semester or post-graduation. The qualitative responses were informative, but these responses were likely impacted by program participation. No follow up occurred to see if these young adult producers really did use their respirators for specified tasks. Due to the short period of time between program delivery and the post-survey, we could not obtain information about potential shifts in respiratory symptoms.

Lastly, the results from this study may not be generalizable to all young adult hog producers since the surveys were focused on young adult producers who were simultaneously enrolled in two- or four-year collegiate agriculture production programs. Education level may have impacted the higher proportions of young adult hog producers reporting respiratory protection usage on the farm, for example. Collegiate education has previously been found to impact the adoption of other hog production management practices and acceptance of technology (Gillespie et al., 2004).

These limitations reflect some of the downsides to using survey data originally intended for outreach purposes. However, to our knowledge this is one of the most extensive survey datasets with regards to respiratory protection knowledge and behaviors reported by young

adults working in U.S. livestock production. The authors believe that valuable trends in self-reported health and safety behaviors may still be assessed.

Conclusions

In this study, we evaluated self-reported respiratory symptoms during agricultural work, respirator use and experience, and perceived value of receiving respirators using Gear Up for Ag™ program pre- and post-surveys from 703 and 212 young adult hog producers in the U.S., respectively. The survey data was originally intended for outreach purposes and was limited by unmatched data and low post-survey response rates. Nevertheless, approximately one third (37%) of young adult hog producers in post-secondary education programs stated that they have experienced cough, shortness of breath, fever/chills after working in dusty areas on the farm. Most (76.2%) stated that they were already ‘always’ or ‘sometimes’ wearing filtering facepiece (N95-style) respirators, and one third (30%) reported experience wearing a cartridge-style respirator, although it was unclear if they were wearing these respirators inside hog barns. These proportions of self-reported respiratory use are much higher than previously observed in agricultural working populations. Only 5% of young adult hog producers in post-secondary education programs reported having ever been fit-tested for a respirator. We have found that young adult male producers were significantly more likely to report use of both respirator types when compared to female producers, both before and after an educational program. These male producers were also more likely than females to engage in high-risk farm tasks such as cleaning out grain bins and mixing or grinding feed. More research should occur to look specifically into why these gender differences occur in livestock production and if more can be done to construct useful outreach resources with information on gender-specific needs. When asked how they would use their respirators, many stated they would use them during powerwashing/disinfecting, when handling feed or grain; during hog loadouts; and for general work in farrowing barns. Educational programs focused on young adult working in agriculture may have something to offer, since it can lead enhanced use of respirators awarded during the Gear Up for Ag™ program and the purchase of additional safety equipment.

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Table 1.

Description of pre- and post-survey variables collected during Gear Up for Ag™ programs (2017-2021).

Survey Variable	Included Photo**	Description
Pre-Survey		
Demographics*		Gender (male/female/other), age category, education level (community college, university), survey completed before or during COVID-19 pandemic
Respiratory symptoms experienced		Shortness of breath, cough, fever, or chills ever experienced with agricultural work (Y/N/Sometimes)
Previous use NIOSH-certified filtering facepiece respirators (N95)	X	Use of N95 respirator in dusty or hazardous environments on the farm (Always/ Sometimes/Never/NA)
Previous use NIOSH-certified cartridge style respirators	X	Use of cartridge style respirator in dusty or hazardous environments on the farm (Always/Sometimes/Never/NA)
Respirator fit testing experience	X	Has ever been fit tested for a respirator (Yes/No)
Post-Survey		
Value in receiving free respirators (N95 and cartridge style)		Perceived value in receiving free respiratory protection during the Gear Up for Ag™ program (Y/N/Not Sure)
Purchased additional NIOSH- certified respiratory protection	X	Purchased additional respiratory protection for self, family/co-workers following program (Y/N/Not Sure)
Used respirators after program	X	Used either type of NIOSH-certified respirators in dusty or hazardous environments on the farm following the Gear Up for Ag™ program (Yes/No)

*Production type was a demographic variable. Only participants who reported hog production were included;

**Indicates that a photo was included in the survey question for clarification.

Table 2:

Demographics of young adult hog producers enrolled in Gear Up for Ag™ programs (2017-2021).

	Pre-survey (N= 703) % *(n)*	Post-survey (N= 212) % *(n)*
Gender		
Male	72.8% (512)	50.0% (106)
Female	27.0% (190)	37.7% (80)
Non-Binary	0.1% (1)	0 (0)
Missing *	0 (0)	12% (26)
Program Location		
University	58.3% (410)	60.8% (129)
Community College	41.7% (293)	39.2% (83)
Age		
18–20 yrs	48.3% (341)	44.3% (94)
21–30 yrs	51.7% (362)	55.7% (118)

* The participant did not complete the survey question.

Table 3:

Common agricultural tasks reported by young adult hog producers in the past 12 months.

Task description	Respirator recommendation**	Proportional response % (N)			
		Total	Males	Females	P-Value
Tasks from 2017–2021					
Working/moving hogs	Recommended if working in dusty buildings or areas	82.8% (582)	80.0% (409)	85.3% (162)	0.103
Unloading/loading hay or feed	Recommended	69.8% (491)	68.6% (351)	66.3% (126)	0.575
Cleaning pens, crates, or housing (includes powerwashing)	Recommended when cleaning generates dust, and when powerwashing or using specific cleaning/disinfectant chemicals	67.4% (474)	66.8% (342)	60.5% (115)	0.575
Feeding hogs†	Recommended	60.5% (425)	61.5% (315)	50.5% (96)	*0.009*
Cleaning out grain bins, or feed bins/ storage†	Highly recommended	58.9% (414)	67.6% (346)	27.4% (52)	*<0.0001*
Mixing or grinding feed†	Highly recommended	45.5% (320)	49.6% (254)	30.5% (58)	*<0.0001*
Tasks added in 2020*					
Administering pharmaceuticals/ vaccines	Recommended if working in dusty buildings or areas	37.9% (85)	35.5% (53)	41.2% (31)	0.401
Transporting hogs on roadways†	Not recommended	31.5% (71)	41% (61)	22% (17)	*0.007*
Taking care of youngstock (piglets)†	Recommended if working in dusty buildings or areas	29.0% (65)	24.8% (37)	46.6% (35)	*<0.0001*
Performing welding tasks on farm	Highly recommended	19.2% (43)	26.2% (39)	5.3% (4)	0.359

*These tasks were added to the survey in 2020; n=224 (75 females, 149 males);

**Recommendations from G. Hetzel (2005);

†Indicates a significant difference observed between males and females using a two-sample Z-test for proportions or two sample chi-square test for proportions if N ≤ 5.

Table 4.

Self-reported symptoms and safety behaviors from young adult hog producers enrolled in Gear Up for Ag™ programs (2017–2021).

Variable		**Proportional response % (N)**			
Pre-Survey		**Total N = 703**	**Males N = 512**	**Females N = 190**	**P-Value**
Ever experienced shortness of breath, cough, fever, or chills ever experienced with agricultural work in a dusty environment	Yes	39.8% (274)	38.5% (197)	40.5% (77)	0.41
	No	49.8% (350)	49.8% (255)	50% (95)	0.41
	Missing *	11.2% (79)	11.7% (60)	9.5% (18)	0.40
Wears a NIOSH-certified filtering facepiece respirator (N95) when performing agricultural work in dusty environments	Always	15.5% (109)	17.1 (88)	13.0 (25)	0.40
	Sometimes †	60.7 5 (427)	64.5 (311)	49.9 (95)	*0.01*
	Never †	10.7% (75)	7.8 (40)	16.4 (31)	*0.02*
	Missing	13.1% (92)	10.6 (73)	20.7 (39)	*0.04*
Ever worn a cartridge style respirator when performing different tasks on the farm	Yes †	30.4% (214)	37.4 (191)	13.1 (25)	*<0.0001*
	No †	59.0% (415)	51.8 (265)	79.0 (150)	*<0.0001*
	Missing	10.5% (74)	10.8 (55)	7.9 (15)	0.26
Ever been fit tested for a respirator	Yes †	5.2% (37)	6.4% (33)	2.0% (4)	*0.022*
	No	72.1% (509)	72.1% (369)	72.6% (138)	0.88
	Unsure	12.7% (90)	10.5% (54)	24.7% (47)	*<0.0001*
	Missing	9.4% (67)	10.9% (56)	0.1% (1)	0.7315
Finds value in receiving NIOSH-certified respirators as part of an educational program	Yes †	78.8% (554)	83.0% (425)	67.4% (128)	*<0.0001*
	No	8.1% (57)	7.0% (36)	11.1% (21)	0.115
	Unsure †	12.7% (89)	9.4% (48)	21.6% (41)	*<0.0001*
	Missing	1.3% (9)	0.5% (3)	0% (0)	“
Post-Survey		**Total** ** **N = 212**	**Males N = 106**	**Females N = 80**	**P-Value P-Value**
Likely to wear the filtering facepiece respirator (N95) received during the program	Very likely	43.3% (92)	45.3% (48)	33.8% (27)	0.112
	Somewhat likely	40.5% (86)	39.6% (42)	50.0% (40)	0.158
	Not likely	8.5% (18)	6.6% (7)	12.5% (10)	0.168
	Missing	7.5% (16)	8.5% (9)	3.8% (3)	0.7956
Likely to wear the cartridge style respirator received during the program	Very likely	35.8% (76)	38.7% (41)	30.0% (24)	0.219
	Somewhat likely	43.4% (92)	41.5% (44)	41.3% (33)	0.968
	Not likely	11.8% (25)	9.4% (10)	18.8% (15)	0.066
	Missing	9.0% (19)	10.4% (11)	10. 0% (8)	0.93
Purchased an additional respirator for themselves or someone else after the program	Yes	20.3% (43)	27.4% (29)	17.5% (14)	0.114
	No	64.6% (137)	71.7% (76)	76.3% (61)	0.484

Variable		Proportional response % (N)			
		Total	**Males**	**Females**	**P-Value**
Pre-Survey		**N = 703**	**N = 512**	**N = 190**	
	Missing	2.8% (6)	0.9% (1)	6.3% (5)	0.842

*Missing = survey question response was blank;

**'Total' of 212 does not equal overall numbers of males and females, n=26 had missing data for gender.

†Indicates significant difference observed between males and females using a two-sample Z-test for proportions or two sample chi-square test for proportions if N ≤ 5.