PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 43, No. 4, p. 316–328
https://doi.org/10.4315/FPT-22-034

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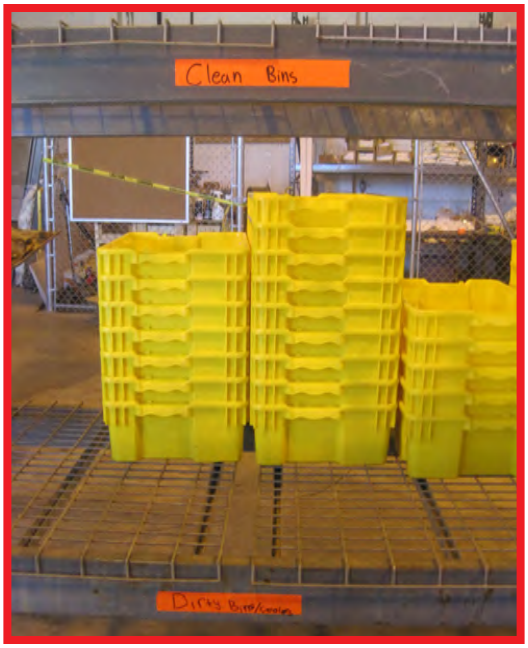

Produce Safety Alliance Training: Long-Term Behavioral Change Study in the North Central Region

ABSTRACT

Starting in 2016, the Produce Safety Alliance (PSA) Grower Training has been offered as the only Food and Drug Administration–approved course to meet the Food Safety Modernization Act Produce Safety Rule educational requirements for produce growers. This study interviewed farmers four to six years after training to measure changes made. Other studies have measured change one year after training. The most common types of changes this study's participants made were in the areas of health and hygiene and preventing cross-contamination. These changes did not differ by farm size. The authors expected farmers would have made more difficult changes, given the greater amount of time between taking the training and the study. However, the greatest barriers to making food safety changes—limited time, money, and labor availability—persisted for study participants. This study also found that human capital was the most effective resource that helped farms make food safety changes. Recommendations based on the study include prioritizing states' federally funded Cooperative Agreement Program (CAP) funds to pay for staff, taking advantage of the three ways to offer the PSA Grower Training, and investing in ways to help overcome the main barriers that growers identified: time, money, and labor constraints.

INTRODUCTION

The research outlined in this paper analyzes data gathered during a long-term behavioral change study that took place at the North Central Region Center for Food Safety Modernization Act Training, Extension, and Technical Assistance (NCR FSMA Center). Specifically, researchers focused on growers who took the Produce Safety Alliance (PSA) Grower Training between 2016 and 2018. Using in-depth interviews, researchers sought to understand the long-term behavioral change (four to six years post-education) of growers, because a literature review of previous research showed all focused on short-term behavioral change (one year posteducation) *(5, 13)*.

The NCR FSMA Center is housed at Iowa State University. Since 2016, the center has supported the infrastructure of the national food safety program by communicating and

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coordinating information within the region related to the Food Safety Modernization Act Produce Safety Rule (FSMA PSR) and Preventive Controls for Human Food Rule. The north central region (NCR) comprises Indiana, Illinois, Iowa, Kansas, Minnesota, Michigan, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

Partnering with universities, colleges, state and federal governments, other produce safety centers and alliances, and nongovernmental organizations in the 12 north central states, the NCR FSMA Center creates a community of educators and regulators who support growers and processors in making decisions that improve produce safety. Center partners have offered the PSA Grower Training since 2016 and collected related knowledge gain and one-year behavioral change data since 2017 *(13)*. From an aggregate of one-year behavior change surveys over a five-year period, 47% of grower respondents reported making a change to on-farm food safety practice only; 26% reported making a change to both practice and infrastructure; and 3% made a change to infrastructure only *(6)*.

Although an increase in knowledge can influence individuals to make more informed choices, this may or may not result in behavioral change *(11, 13, 14)*. Pilling et al. *(14)* proposed that food safety training should take into account factors that affect behavior, including attitudes, subjective norms, and perception of control. Arlinghaus and Johnston *(1)* simply stated that "Knowledge is not enough to change behavior. If it was, no one would smoke or overeat to the point of becoming obese, and everyone would wear seatbelts and exercise. However, knowledge is important. It is critical to explain to [learners] why behavioral changes need to be made." Pratt and Bowman *(15)* suggested that the likelihood of knowledge application increases when specific knowledge and skills are identified and supported, because this creates the foundation for new behaviors *(3, 15)*.

This research seeks to fill a void in the literature related to the long-term impact of produce safety education on produce growers' behavior. Objectives include identifying factors that have facilitated behavior change, as well as barriers to making changes, and sharing recommendations to help farmers tackle challenging changes.

MATERIALS AND METHODS

Researchers at the NCR FSMA Center worked with eight state partners to recruit growers to the study. These partners worked for state departments of agriculture or university extension services and had access to the list of people who took the training in their state. Eight partners represented Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, South Dakota, and Wisconsin. These partners numbered the list of growers who had taken the PSA training between July 2016 and June 2018 in the respective state. The researchers provided each partner with a list of randomly selected numbers. The partners invited the growers who corresponded with each number to participate in the study. If a grower declined to participate, the partner moved on to the next random number. Partners provided the research team with the contact information of growers who agreed to participate in the study. The research team contacted these growers via email or phone to provide informed consent documentation, and 37 growers agreed to participate. Of these, 23 growers completed the study interview and farm demographics survey. Interviews were conducted over the phone, and the survey was administered in Qualtrics or over the phone at the same time as the interview. The interviews were semistructured using a common template, recorded, and transcribed using the Rev Recorder app. On average, interviews lasted 15.8 min.

An NCR FSMA Center partner in Wisconsin arranged for one researcher to interview Amish producers (Plain Clothes Growers) in person at an auction where they sell their produce. Seven Amish producers completed the survey and interview. These interviews were not recorded, because recording technology has not been used by that community. Therefore, the researcher took extensive notes of their responses. The survey was conducted verbally with these participants, and interviews were semistructured using the common interview template. All growers who completed the study were offered an honorarium of a $75 gift card, or $75 cash in the case of Amish growers.

The farm demographic questionnaire asked the following:

- Number of years the respondent has been selling fruits or vegetables,
- Number of acres on which they grow fruits and vegetables in outdoor plots,
- Square footage on which they grow fruits or vegetables indoors or under cover,
- Fruits or vegetables they grow,
- Average gross sales of fruits and vegetables per year,
- FSMA coverage status,
- Special populations to which the respondent may belong,
- Gender,
- Whether they have had a FSMA PSR inspection, and
- To what markets they sell fruit or vegetables.

The questions asked in the farm demographic survey are included in Appendix A. The interview template asked respondents the following:

- What they recalled from the training;
- What changes had respondents made to improve food safety practices and infrastructure since attending the training;
- Which people, organizations, or information sources helped respondents to make produce safety changes;
- Where they get updates about on-farm food safety;
- Changes they need to make but have not implemented;
- What has prevented them from making changes; and
- Whether the training changed their mindset on produce safety.

TABLE 1. Demographics and farm characteristics of participants

	Mean (SD)[a]	Median
Years selling fruits or vegetables (n = 30)	12.6 years (9.3)	9.5 years
Acreage of fruits or vegetables grown in outdoor plots (25 participants)	14.2 hectares (41.3)	2.02 hectares
Area of fruits or vegetables grown indoors or under cover (18 participants[b])	698 m^2 (1,061)	293 m^2

[a]SD, standard deviation.

[b]Area of fruits or vegetables grown in indoor plots does not include four Amish growers who indicated they had greenhouses or high tunnels but did not specify the area.

TABLE 2. Demographics of study participants

Special population	No. participants (n = 30)[a]
Local food producer (majority of produce sold within 250 mi. of farm)	20
Amish	7
Limited resource farm	5
None	3
Racial or ethnic minority	1
Female	18
Male	12

[a]Numbers do not add to 30, because participants could choose more than one answer.

The interview template also included optional prompts that the interviewer could ask based on respondents' answers. The interview template can be found in *Appendix B*.

Five researchers independently coded the transcripts for themes, using NVivo software (Burlington, MA) to organize the codes. Grounded theory guided the analysis, so theory emerged from the data, rather than analyzing the data with a preconceived theory *(7)*.

This study was deemed exempt by the university's Institutional Review Board. All researchers completed the university's Institutional Review Board Human Subjects Training.

This paper provides information on the produce growers who participated in this study and then explores the following research questions: (1) What topics covered in the PSA Grower Training resulted in the most knowledge and behavioral change among produce growers in the NCR? (2) What is the relationship between size of produce operation and knowledge and behavioral change following the PSA Grower Training? (3) What are the most effective conditions and resources to improve knowledge and behavioral change? (4) What are the barriers that prevented produce growers from making knowledge and behavioral changes?

RESULTS

Response rate

Although researchers had a goal of including 50 research participants, 30 growers participated in the study. According to the PSA, 2,929 people from the eight states participating in the study had taken the training by December 2018. Therefore, this study reached 1.0% of all participants. In a review of 171 journal articles about grower behavioral change, researchers found 42 articles that used interviews only as the way to measure the effectiveness of the intervention. The median size of those studies was 43 interviewees *(17)*.

Participant characteristics

All research participants completed the farm demographic survey. *Table 1* shows that on average, participants have been selling fruits or vegetables for 12.6 years, with a median of 9.5 years. Eighteen participants indicated they had production both indoors and outdoors, seven participants farm outdoors only, and five participants farm indoors only. Those who grew fruits or vegetables in outdoor plots grew on an average of 14.2 hectares and a median of 2.0 hectares. The average (14.2

hectares) was skewed higher than the median (2.0 hectares) because two participants were outliers, producing on very large farms (more than 40.5 hectares). Both were tree fruit farmers. On average, those who grew produce indoors had 698 m^2 under cover, with a median of 293 m^2. In addition, four growers, all Amish, indicated they had greenhouses or high tunnels but did not specify the sizes.

Eighteen females (60%) and 12 males (40%) participated in the study *(Table 2)*. All but three participants identified with a special population (participants could select more than one special population). Twenty indicated they were local food producers, meaning that most of their produce was sold within 250 miles of the farm. Seven were Amish, five operated limited resource farms, and one identified as a racial or ethnic minority.

Study participants operated small farms in terms of sales *(Table 3)*. They most commonly sold $25,000 or less of produce annually (13 participants) or between $25,001 and $250,000 (13 participants). Two participants sold between $250,001 and $500,000 per year, and two growers sold more than $500,000 per year, on average.

Growers belonging to all FSMA coverage categories participated in the study. The most common category was qualified exempt (11 participants), closely followed by not covered because they sold less than $25,000 per year on average (10 participants), fully covered (8 participants), and not covered because they did not grow covered produce (1 participant) *(21)*. However, seven participants shared answers that appeared to contradict with the FSMA coverage status that they selected. For example, two growers indicated they were fully or partially covered by FSMA but also indicated they sold less than $25,000 per year of produce, although any grower who sells less than $25,000 per year of produce is not covered by FSMA. This error could indicate that some participants were mistaken about their FSMA coverage status, annual sales, or markets. Eleven participants (37%) indicated they had been inspected for the FSMA PSR, and 19 participants (63%) indicated had not, although 1 grower later clarified it was a Good Agricultural Practices (GAP) inspection.

What topics covered in the PSA Grower Training resulted in the most knowledge and behavioral change among participants?

Cross-contamination was mentioned by 23 participants. This subject was often brought up in relation to other topics, such as handwashing, water quality, animal feces, and cleaning and sanitizing equipment and produce. One participant stated, "So I know they talked a lot about cross-contamination; I know that was something that kind of stands out, and how to prevent cross-contamination."

As for changes participants made regarding cross-contamination, three participants did not wash produce anymore after they learned from the PSA Grower Training that washing produce was not required under the FSMA PSR, which helped reduce the chances of contaminating produce by minimizing the number of times produce is handled. Three growers mentioned they minimized the number of times produce is handled by placing harvested produce directly in crates ready for sale.

When asked to share which information they remembered from the training, 22 participants mentioned health and hygiene, mostly related to handwashing. One participant stated, "Well, I suppose the main thing is just that no matter what, you just wash your hands constantly and just keep everything as clean as you possibly can." Nine growers made changes in their operations to facilitate handwashing. Changes included installing designated handwashing sinks, emphasizing the importance of handwashing during employee training, and not using the handwashing sink for washing produce. (Some participants did not distinguish between handwashing stations and sinks for normal cleaning of tools.) Two participants said that before the training they used gloves when handling produce and did not think hands needed to be washed before donning gloves. After the PSA Grower Training, the participants no longer required employees to wear gloves when handling produce. Instead, they emphasized thorough handwashing.

Cleaning and sanitizing was another prevalent topic, brought up by 22 participants. Specifically, the cleaning and sanitizing of equipment such as harvest tables, picking and packing containers, pack sheds, and sinks were mentioned. "You need to clean equipment before you sanitize it. Sanitize[ing] alone isn't something that…qualifies as safe cleaning," stated one participant. Another participant explained how he ensures the cleanliness of the surfaces his produce touches: "We wash it [the harvest table] down with soap and water and then spray a disinfectant on it to make sure that anything we may have missed with the soap and water is killed with the disinfectant."

As for changes made, most growers improved their cleaning and sanitizing practices by adding a sink for washing crates or containers and tools, modifying the workflow, training employees, limiting animal movement throughout the farm, posting signage for guests and visitors, and having a written food safety plan.

Eighteen participants recalled information related to water quality and water testing. A participant said, "I remember water testing. And I remember being careful of contaminants. I remember different types of water, how often they needed to be tested." One participant went into detail about water testing and how to use that information: "We look for coliform, *E. coli*…we test for even pH levels and levels of our chemical mix in it…and then it gives us a score of how likely it is…that something worse could happen over the years and gives you a history score."

Animal feces were mentioned by 17 participants, usually related to contamination. Three participants recalled the importance of maintaining separation between livestock and produce.

TABLE 3. Farm operation characteristics

Crops grown by participants	**No. participants (n = 30)[a]**
Vegetables, mixed	20
Other[b]	15
Leafy greens	14
Berries	10
Tree fruit	6
Tree nuts and/or peanuts	0
Average gross sales	**No. participants (n = 30)**
$25,000 or less	13
$25,001 to $250,000	13
$250,001 to $500,000	2
$500,001 or more	2
FSMA coverage status	**No. participants (n = 30)**
Qualified exempt	11
Not covered because you sell less than $25,000 per year on average	10
Fully covered	8
Not covered because you do not grow covered produce	1
Marketing channels used by research participants	**No. participants[c] (n = 26)**
Farmers' markets	10
Grocery stores	8
Restaurants	7
Community-supported agriculture	7
Farm stands	7
Auctions	6
Institutions	5
Farmer's co-op	2
Distributer	1
Processor	1
Onsite store	1
Other: Donations	3
Other: Direct to consumers	2
Other: Sale for inclusion in WIC[d] boxes	1

[a]Numbers do not add to 30, because participants could choose more than one.

[b]Other crops grown include pumpkins (6 participants), herbs (4 participants), mushrooms (2 participants), edible flowers (1 participant), exotics (ginger and turmeric, 1 participant), and vegetable and fruit starter plants (1 participant).

[c]Four respondents did not answer this question. Numbers do not add to 26, because participants could choose more than one.

[d]WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

"I remember they talked about runoff, of making sure that your gardens or your growing areas being so far away from other livestock, just making sure that stuff wouldn't get contaminated." Others were able to tie this topic back into handwashing by explaining how their employees have been required to wash their hands between livestock areas and produce areas to reduce cross-contamination. In addition, seven participants shared what they recalled about composted animal manure. One stated, "I know you don't want to be growing fresh lettuce in fresh animal manure." For others, the information was new: "I didn't know a lot about compost and what was considered safe and not safe."

Eight participants implemented better animal control measures such as installing fencing, holding animals away from produce, restricting the movement of domestic pets on the farm, monitoring the farm for animal droppings, and creating exclusion zones. Participants expressed challenges with animal control, such as birds flying overhead and wild animals entering the field. Yet the PSA Gower Training made participants more aware of ways to implement animal controls and what to look for and do in the event animal droppings are found on produce.

Three participants developed a farm food safety plan detailing the steps and processes to follow for food safety. One beginning farmer explained how learning about FSMA at the training motivated him to write a plan. "Knowing that there was this whole set of rules made me determined that we were going to have a food safety plan at our farm."

How did the training affect farms of different sizes?

Comparing grower responses by farm size, there appeared to be only slight differences in what growers recalled from the PSA training. For example, the only two growers to bring up traceability were from farms with large outdoor acreage, specifically 500- and 50-acre farms, which were the largest and fourth largest out of the 30 participants' farms. One grower stated, "We always hit big on traceability. So, when they were going over that kind of stuff, we always take extra notes on that… I can't really trace a whole apple back to a tree. I can get back to a block in a row, maybe." Other topics mentioned by growers from larger farms were water quality, cross-contamination, handwashing, personal hygiene, cleaning and sanitizing, manure, and animal control (restricting animal access on the farm and preventing contamination of produce from feces).

The topics mentioned by participants with smaller farms were similar to those of the medium and large farms. They recalled handwashing, water quality, compost, and cross-contamination topics. One topic that was consistently mentioned by growers with smaller farms was cross-contamination between produce and livestock or animal feces. This was mentioned by 7 of the 10 small growers. One participant stated, "Well, I mean because we're so small, I mean it's not like we had to practice any of them [PSR requirements], but I did remember silly things like…making sure there's no poop within X amount of feet of some of the harvested produce."

Seven Amish growers were interviewed, but the topics they discussed were not notably different from other growers. Five of the seven growers recalled the topic of handwashing from the PSA training. Three growers mentioned the importance of documentation, such as standard operating procedures (SOPs) and training logs: "Training logs and SOPs are now clearer… I understand how to use them and why." Two of the seven recalled the topic of record keeping. One grower stated, "Record keeping has been the main thing."

What conditions and resources facilitated making on-farm food safety changes?

Participants identified university extension services as the number one resource that has helped them to make food safety changes on their farm; 21 participants mentioned extension services. For example, one shared how an extension employee helped identify a need to improve employee training during a visit, "The gentleman at [a state university] actually came out to the farm and walked through food safety, inspection-ish. That was very informal, but that was really helpful, too, in just pointing out areas that could be problem[atic]. And, actually, that really raised the [employee] training question. It brought that to the forefront after he talk[ed] to employees."

A few participants explained that their interactions with extension staff were multifaceted. They received many types of trainings or resources from extension services, not just food safety–related resources. One said, "It was all through [our state university extension program]. They do both the Good Agricultural Practices (GAP) training and the business training."

Seven participants described extension employees as their go-to people or resources. One said, "[The food safety specialist] at [our state] university is always very, very helpful. Whenever I have a question, she's usually…my go-to person." They described extension specialists as accessible. "[The extension agent] gave us his cell phone number, plus I've got his email. We can contact him at any time if we have a question on basically anything that has to do with GAPs or the business."

Seventeen participants indicated that they were GAP certified, and another had started the process of receiving that certification to meet buyer requirements. For these growers, the resources provided by their auditor helped them make many of the food safety changes that they have made on their farms. One said, "With GFS Food Safety, through the Azzule and Primus…they make sure that everything is [in compliance]. Those would probably be our biggest resources."

Not surprisingly, participants who were already GAP certified or who had previously taken food safety classes

indicated the PSA Grower Training was not as impactful as it was for those who had previously never taken a training. For example, one GAP-certified grower said, "I felt like our business didn't get as much from [the training], just because we had already gone through a lot of training, and I felt like that was more of an introductory kind of class."

Two participants described joining a family farm business that was well established. Both farms had been selling to their market and following buyer requirements for food safety for decades. They described making continuous improvements, building upon what was already happening on the farm related to food safety. Similarly, another explained the benefits of farming for many years because the business has become more financially stable than in earlier years. "Some improvements that we've made as we mature as a farm and as a business, is we just have more money and resources available to us. So, we continue to invest a certain amount every year into improvements in all aspects of the farm."

Nine participants explained that they receive updates on food safety through email. These updates come from various sources, including extension services, state departments of agriculture, and the PSA.

Five mentioned FSMA regulators as a helpful resource. They described their regulatory agencies as fulfilling educational roles both during inspections and outside of inspections, such as attending or teaching PSA Grower Training and/or On-farm Readiness Reviews. According to one participant, "[Our state FSMA inspector] came out last year and they did another inspection. Every time you get inspected, they always sort of give you pointers as to what to improve and they try to keep up with any new information coming down the line."

Four participants learned food safety information from farmers' market vendors or managers: "We have one lady that kind of oversees everything [at our market], so she always keeps us up to date on any changes that come across… she always wants to make sure that we do it right, I guess. I mean they've taken classes or take other things, are always trying to stay up to date and stuff, and encouraged us to do the class." Similarly, three Amish growers identified their auction manager or the auction board of growers as sources of food safety information.

Participants also drew upon other life experiences, including health management, teaching, food processing, and foodservice, and applied what they had learned to food safety on their farm. One said, "I think [the PSA Grower Training] reinforced things… I was a science teacher, so in terms of bacteria and pathogens, you know, that's totally in my knowledge base." Another said, "So FSMA hasn't been super confusing to me… It is just best practice in food handling, in general, or how I was trained before I came into farming."

What food safety changes do growers want to make, and what has prevented them?

Most participants mentioned their desire to make changes every year on their farm, but time, infrastructure-related expense, and labor were barriers. Regarding lack of time, one participant said, "I am always behind on projects… I have lots of things that I want to do but I'm behind." The theme of time was also mentioned with regard to water testing and use. A few participants mentioned the desire to test water more frequently and finding alternative water supplies. Time was the main reason for not doing this sooner. For example, one shared, "For me, [the challenge is the water testing] frequency just because that takes me away from here every time I have to go… it's hard to fit it in the schedule." When asked whether the grower planned to implement certain changes that had been referenced earlier in the interview, one participant replied, "No, not right now. Right now, I think we're trying to do so many things. I'm sure we'll evolve each year, hopefully to be a better producer." This feeling was shared by many of the producers interviewed.

Finances are especially a barrier to improving infrastructure. One participant explained, "You got to sell a whole lot of bunches of kale to be able to afford to buy big fancy refrigerators and cleaning stuff." Another participant said, "We also would like to expand our cooler to have different incoming and outgoing areas that would help with cross-contamination, things like that. And again, it's really just the money that it takes to keep up or to upgrade some of those areas." Other barriers that were brought up in the interviews related to the cost of changing infrastructure include a lack of space, insufficient handwashing stations, poor irrigation, and poor drainage.

Another notable barrier was availability of labor. Some participants discussed difficulties in finding skilled laborers to help them improve infrastructure. "I think that's going to be a forever project of actually getting somebody that can come out here. It's difficult to find some people in the trades that want to come out to the rural setting, which is understandable," said one participant who wanted to hire a plumber to upgrade the produce washing line. Another had a similar sentiment and said, "Then it's finding people that are available, because the labor market right now is just bonkers tight. You can hardly find anybody doing [these jobs]."

Some participants noted a lack of prior food safety training as a barrier they experienced before attending the PSA training. One participant wished they had taken food safety training earlier, stating, "It's a good idea to have the training right up front before you ever get in a position where you've done something you shouldn't have just because you didn't know what you were doing." Interestingly, given the timing of the interviews (2022, two years after the start of the COVID-19 pandemic), COVID-19 did not emerge as a theme in this study and was only mentioned by three people.

Improving infrastructure was the change participants most wanted to make in the future. These changes included updating packing sheds, handwashing stations, bathrooms, and equipment. They were deemed necessary to improve

cleaning and sanitation and to minimize cross-contamination. Participants wanted to ensure their equipment was clean and the environment did not promote pathogen survival. Handwashing stations were present on most farms, but participants wanted more stations located throughout the farm for easy access. One said, "We are going to add hand washing stations in the field where we have pickers." Many participants were concerned about the flow of produce from harvest to packaging. They expressed a desire to change the packing shed and overall infrastructure to control these food safety concerns. One hydroponic greenhouse grower said, "It'd be nice to have a completely separate room where we do all the harvesting, just because it would be easier to control the environment." Another said, "We're still trying to get a packing shed put up where we'll have the sink, the triple utility sink and everything. So, we can clean and sanitize our utilities but much easier than we are now." Improvement of equipment was mentioned somewhat frequently. Comments included the improvement of packing bins, harvesting tools, and refrigeration and cooling units, as well as changing equipment types to stainless steel. Participants knew their current equipment needed improvement, but financial shortfalls were the top reason for not getting these items replaced.

Another frequently mentioned area of improvement for the future was the separation of livestock from growing areas. Many of the participants mentioned having a mixed farm; therefore, they struggled to prevent contamination between livestock and produce. Employee management between the two operations, handwashing, and livestock entering produce fields were the most frequent comments. One explained, "[We need] better separation between livestock operations and produce operations… We've got cattle and goats on one side of the fence, and they've been known to break into the produce operation."

Another theme was related to training and improving the SOPs on the farm. Participants desired to do more training with their employees and improve their policies and procedures to ensure their employees were doing things correctly. Cleaning and sanitizing and helping employees know how to identify food safety concerns were the most frequent reasons for wanting to improve. One said, "[I need to] try to be more organized and to communicate with my fellow co-workers about what we do and why."

DISCUSSION

Participant characteristics were fairly consistent with data reported from the 2017 Census of Agriculture (the most recent census) *(19)*. For instance, 27% of U.S. farmers have been farming for 10 years or less and the remaining 73% have been farming for 11 years or more, whereas more than half of the research participants had been farming for 10 years or less. Only one participant reported being a member of a racial or ethnic minority group. This lack of racial or ethnic diversity among participants was consistent with Census of Agriculture demographics, which showed that 95% of U.S. growers were white *(19)*.

Some of the produce growers interviewed shared what seemed to be contradicting information about their FSMA coverage status. For example, two indicated they were fully or partially covered by FSMA but also indicated they sold less than $25,000 per year of produce, although any grower who sells less than $25,000 per year of produce is not covered by FSMA. In a study evaluating produce farmers in Minnesota, Omolo *(12)* noted this lack of synergy as well and suggested that it may be as a result of challenges in understanding the exemption criteria for the FSMA PSR.

Personal hygiene, with an emphasis on handwashing, was frequently mentioned in the interviews. In a review by Chen et al. *(5)*, the authors reported that growers and farmworkers pay close attention to personal hygiene, including handwashing, even though the actual practice varies greatly in consistency. Similarly, regulators highlighted these same topics when discussing areas of on-farm noncompliance in the northeast region at the 2021 Produce Safety Workgroup Meeting *(16)*. Inspectors and growers may have different interpretations of the standards. It is also possible that growers have made changes to personal hygiene practices that brought the farms closer to, but are not yet up to, the PSR requirements.

The study participants highlighted the value of people as resources, with specific mention of extension staff, market or auction managers, and employees of state departments of agriculture. (The authors acknowledge that the growers most likely to answer a phone call or email from their extension agent and agree to participate in this study were the growers with the most positive relationships with the extension agent. This might have influenced how often extension agents were mentioned as a helpful resource.) Although extension agents likely share online or print resources with growers, participants did not often mention these resources. Rather, they described the agents themselves as being resources. According to Smith et al. *(18)* outstanding extension agents have a focus on relationships, expertise, and an ability to quickly provide answers. This observation was supported by the participant responses in this study. Ivey at al. *(8)* underscored this point in stating that "Vegetable producers preferred in-person modes of communication over mass media, fact sheets or electronic modes, with only 17% having a preference for internet or email-based information."

The similarity in content recalled by growers with small and large farms mirrored the observations reported by Marine et al. *(10)*, who noted that the practice of on-farm food safety did not differ across farm scale or years of experience. The key influence on grower decisions was the market channel, primarily driven by demands from buyers *(10)*. The mention of traceability by only two of the largest growers in the interviews was notable. The traceability

rule had not yet to be finalized at the time the research was conducted (early 2022), so it might have been hard for growers to devote much time to implementing the practices, but large growers may have already implemented traceability systems to meet buyer requirements *(20)*. The Food Traceability Final Rule was published by the Food and Drug Administration on November 17, 2022.

Ironically, those who were required by law to take the PSA training were the least likely to find it useful. More than half of the participants in the study managed farms that were GAP certified to meet buyer requirements—often the requirements of processors, an auction house, or intermediated markets. These growers tended to operate larger farms, were more likely to be covered by FSMA, and thus, were required to attend the training. Many of them considered the PSA training a refresher but otherwise not very impactful, because they were already implementing needed practices. However, those who were not required to take the course, because they operated qualified exempt farms or farms not covered by the PSR, were more likely to find the training useful. These growers tended to operate smaller farms that relied primarily on direct-to-consumer markets, which do not require food safety practices. In the previously mentioned NCR FSMA Center follow-up survey, frequency of on-farm food safety change was compared among farms of each FSMA coverage status (fully covered, partially covered including qualified exempt, not covered, and unsure). The fully covered (larger) growers made food safety practice and infrastructure changes at the second-lowest rate of all growers, at 71% *(6)*. The only group that made fewer changes were the growers who do not grow covered produce (those not covered by the PSR), 63% of whom made a change. In contrast, 86% of people from farms that were eligible for a qualified exemption and 81% of those from farms that were not covered by FSMA because they sold less than $25,000 of produce annually reported making a change to food safety practice, infrastructure, or equipment in the year after attending training *(6)*.

The participants shared several food safety improvements they hope to make on their farms but mentioned that time, money, and personnel were limiting factors. These changes and barriers were consistent regardless of the number of years after training, as noted by comparing the interview results with an NCR FSMA Center one-year follow-up survey *(6)*. As one grower called it, these were "forever projects." One might have expected growers to make easy improvements, such as to hygiene practices, in the first year after training and later make the harder or more expensive changes, such as replacing equipment or improving infrastructure. However, these interviews showed that even four to six years after attending the training, many participants had not yet made the more difficult changes that they would like to make, such as improving pack shed structures. There were exceptions to this, as two growers mentioned making improvements every year, especially as the farm made more profit.

In a 2018 study, the U.S. Department of Agriculture (USDA) Economic Research Service estimated the cost for produce growers to comply with the PSR. Large farms with sales over $3.45 million would incur a compliance cost of about 0.3% of the value of produce sales annually. Medium sized farms ($500,000–$700,000) would spend about 4.2%. Small farms ($250,000–$500,000) and very small farms ($25,000 and $250,000) were estimated to incur annual costs of 6.0% and 6.8%, respectively *(4)*. More targeted research should be done to determine, first, why exempt farmers are adopting requirements stipulated in the PSR, and second, how much it is costing them to do so. This voluntary adherence to food safety practices may be an indicator of growing awareness of food safety risks associated with fresh produce and a commitment on the part of farmers to protect consumers from foodborne illness. In addition, exempt farmers may be adopting food safety practices for their own risk management or in response to market pressure *(2)*.

Labor shortages were also an ongoing concern. The situation may have been challenging before but was exacerbated by the COVID-19 pandemic, as highlighted in an article in The Produce News *(9)*. In addition, research study participants did not mention the need for further education as a barrier to making further on-farm food safety changes. The NCR FSMA Center one-year follow-up survey also noted that lack of knowledge or need for technical assistance were less common barriers *(6)*. Therefore, going forward, extension services and state departments of agriculture or health may need to focus on relationships with growers and addressing the barriers of lack of time, money, and labor, rather than on education.

CONCLUSIONS

Participants remember key information they learned at the PSA trainings they attended four to six years ago and have implemented changes that were within their available resources. The training was effective in teaching food safety concepts to growers, especially those who had not previously participated in food safety training. Recognizing that the primary barrier to making on-farm food safety changes is not a lack of education but rather the lack of time, money, and labor, additional advocacy needs to be made to support sustainability in the fruit and vegetable industry.

The authors were expecting to see more robust changes in relation to infrastructure (packing sheds, handwashing stations, etc.). However, many growers were still listing the same changes that were noted from growers one year after training. This is because the major barriers, including time, money, and personnel challenges, still exist. Although the authors are extension educators whose tendency is to address these challenges by creating tools to save time and money, such as spreadsheets, forms, or templates, this research showed growers were more likely to request an educator's time than tools and were more likely to use the many existing tools that had been personally recommended to them.

The authors recommend the following to help farmers reach compliance with FSMA and support those not covered by FSMA:

- One of the biggest resources and sources of produce safety updates mentioned was extension agents and employees of state departments of agriculture or health. CAP recipients might consider prioritizing their federal CAP funds to pay for staff.
- CAP recipients should take advantage of the three ways to hold the PSA grower training. Using multiple options could be beneficial as states continue to offer the course even as most growers covered by FSMA have taken it. Offering multistate, remote trainings might allow states to continue to offer PSA trainings in an economical way to the few covered growers who have not already completed the course. In addition, states could consider using their CAP funds to subsidize the cost of the online PSA Grower Training. This independent study version of PSA Grower Training might be an effective program for some growers, especially if states could cover some costs, similar to the way most states subsidize the in-person and remote versions of the course. Going forward, extension staff may want to consider offering GAP training to growers on small farms who have not been covered by FSMA, instead of the certificate-earning PSA Grower Training.
- Extension educators and state departments of agriculture or health should invest in ways to help overcome the main barriers that growers identified: time, money, and labor constraints. They might share grant opportunities (such as the 2022 Food Safety Certification for Specialty Crops Program or Natural Resources Conservation Service funding) and share stories of growers who have made cost-effective or time-saving changes.

ACKNOWLEDGMENTS

This work was supported by the Food Safety Outreach Program (grant 2018-70020-28877) from the USDA National Institute of Food and Agriculture. We acknowledge all parties who recruited growers for this study. Specifically, we thank Kansas State University, Purdue University, Michigan State University, Minnesota Department of Agriculture, University of Missouri Columbia, Purdue University, South Dakota State University, and Wisconsin Department of Agriculture, Trade, and Consumer Protection.

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APPENDIX A. Farm demographic survey questionnaire

1. How many years have you been selling fruits or vegetables? _____
2. On how many acres do you grow fruits or vegetables in outdoor plots? _____
3. On how many square feet do you grow fruits and vegetables indoors or under cover (such as but not limited to greenhouses and high tunnels)? _____
4. Please select the fruits and vegetables that you grow to sell. (Choose all that apply.)
   (If verbal, please say yes or no after each crop that I am going to list.)
   - ❑ Tree fruits (apples, pears, etc.)
   - ❑ Berries (strawberries, raspberries, etc.)
   - ❑ Leafy greens
   - ❑ Peanuts/tree nuts
   - ❑ Vegetables, mixed
   - ❑ Other (please specify) _____
5. Please select your average gross sales of fruits and vegetables per year:
   - ❑ $25,000 per year or less
   - ❑ Between $25,001 and $250,000 per year
   - ❑ Between $250,001 and $500,000 per year
   - ❑ More than $500,000 per year
6. Please share which you believe is your FSMA coverage status:
   - ❑ fully covered
   - ❑ qualified exempt (this is where you sell between $25,000 and $500,000, adjusted for inflation, and over half of produce is sold to qualified end users)
   - ❑ exempt because produce goes through a kill step
   - ❑ part of farm is required to comply with FSMA and part is not
   - ❑ not covered because you sell less than $25,000 per year on average
   - ❑ not covered because you do not grow covered produce

7. Do you identify with any of the following farmer demographics? (Choose all that apply.)
(If verbal, please say yes or no after each demographic that I am going to list.)
   - ❑ Amish
   - ❑ Mennonite
   - ❑ Local food producer, meaning the majority of your produce is sold within 250 miles of the farm
   - ❑ Tribal grower
   - ❑ Racial or ethnic minority
   - ❑ Non-native English speaker
   - ❑ Limited resource farm
   - ❑ None of the above

8. What is your gender? _____

9. Have you had a Food Safety Modernization Act (FSMA) Produce Safety Rule inspection?
   - ❑ Yes
   - ❑ No
   - ❑ Unsure

10. Where do you sell fruits and vegetables you produce? (Choose all that apply.)
   - ❑ Farmers' market
   - ❑ Farm stand
   - ❑ Roadside stand
   - ❑ Community supported agriculture
   - ❑ Restaurant
   - ❑ Grocery stores
   - ❑ Distributor
   - ❑ Processor
   - ❑ Food hub
   - ❑ Schools, early-care sites, colleges or other institutions
   - ❑ Other (please specify) _____

APPENDIX B. Interview template

1. I know you took the grower training about the Food Safety Modernization Act (FSMA) Produce Safety Rule a long time ago. Can you share two or three things about produce safety that you remember from the training?

   Intent: Understand parts of the training that are particularly impactful. Guide our trainers toward sharing relevant information or using effective methods.

   a. Probe: Please describe what you remember and how it has impacted you.

   b. Probe: Can you share anything specific related to (topic mentioned earlier) that you recall?

2. Since taking the Produce Safety Alliance Grower Training several years ago, please describe any changes you have made on your farm to improve food safety practices and infrastructure.

   Intent: Identify changes the participants have made since the training. Help participants start to think about the changes they have made on their farm to prepare them for answering the next questions.

   a. Prompt: Some examples include different cleaning or sanitizing practices, adding handwashing stations, adding portable toilets, changes to how you transport produce, upgrading packing lines, creating clean zones in buildings, changing picking containers to something that's easier to clean and sanitize, etc.

   b. Prompt: Do you recall making any other changes to improve food safety?

3. Please identify any people, organizations, or information sources that have helped you to make those produce safety changes.

   Intent: Understand where people are finding the most useful information or supports to help them make food safety changes on their farms. Help our trainers know the most impactful places to put their resources and to send growers who are looking for support.

   a. Prompt: Some examples might be extension, a fruit and vegetable growers association, a website, a handout, etc.

   b. Prompt: What about (person/resource) has been helpful to you?

4. Where do you get updates about on-farm food safety today?

   Intent: Understand where people are finding information about FSMA. Help our trainers know the most impactful places to put their resources and to send growers who are looking for information.

   a. Prompt: You might get produce safety updates from organizations you belong to, a newsletter you receive, or consultants you talk to.

   b. Prompt: How did you get connected with (source mentioned)?

5. Can you please share any changes you know that you need to make to improve your food safety practices but haven't done?

   Intent: Help us identify the changes that are most difficult to make. Help us understand the barriers to change on a deeper level so that our trainers and departments of agriculture can partner with farmers on solutions.

Please ask one of these follow-up questions:

   a. If they are able to identify changes they need to make: What has prevented you from making those changes? Can you think of anything that would help you to make those changes?

   b. If they can't think of any changes they need to make: What other information or training do you think might help you identify changes you need to make?

6. Did the grower training change your mindset about produce safety in any way?

   Intent: Measure attitude change. Understand if attitude change might correlate with changes discussed earlier.

   a. Prompt: To what extent do you believe parasites, bacteria, and viruses are a risk on your farm?