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Small- and Medium-Scale New England Produce Growers' Knowledge, Attitudes and Implementation of On-farm Food Safety Practices

ABSTRACT

A survey was designed and administered to measure knowledge of and attitudes toward on-farm food safety among small- and medium-sized farms in the New England (NE) region (CT, MA, ME, NH, RI, VT). Two methods of distribution were used, based on each state project director's solicitation preference: an on-line survey was distributed through E-mail, and a paper survey was mailed. Survey responses were analyzed using descriptive statistics, 1-way ANOVA and t-tests, using SPSS software, and significance was reported at $P < .05$. Respondents from small (n = 254) and medium (n = 47) farms had an overall correct knowledge score of 77 ± 13%, related to on-farm food safety practices in the areas of general food safety, water, health and hygiene, planting/growing/harvesting, post-harvest, animal and pest control, and recall/traceback. Knowledge scores were significantly ($P < .05$) higher among respondents who had received GAP training (80% vs. 73%) and had implemented on-farm food safety practices (79% vs. 71%). The overall attitude score, based on a 5-point Likert scale, was 3.5 ± 0.5, reflecting the importance of on-farm food safety, trust in others to keep produce safe, perception of local/smaller being safer, and perception that their customers value food safety. On-farm food safety had a positive attitude score (4.0 ± 0.9), while trust in others had a low score (2.4 ± 0.8).

INTRODUCTION

In 1998, the United States Food and Drug Association (FDA) and United States Department of Agriculture (USDA) launched the produce safety initiative by developing a guide based on basic principles and practices associated with minimizing microbial food safety hazards for fresh fruits and vegetables *(44)*. These Good Agricultural Practices (GAPs) have served as the basis for voluntary on-farm food safety strategies for many years. However, produce-related foodborne illnesses have continued to contribute significantly to the overall outbreak and illness data.

Of the often reported Center for Disease Control and Prevention (CDC) estimates of 48 million cases of foodborne illness, 128,000 hospitalizations and 3,000 deaths *(33)*, annu-

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ally in the U.S., consumption of produce has been reported to contribute to 46% of the foodborne illnesses and 23% of the deaths *(23)*. The highest percentage of illnesses has been attributed to leafy vegetable commodities (22%) *(23)*. Produce-containing foods were the source of approximately half of norovirus outbreaks, with an identified simple food vehicle during 2001–2008 *(18)*, and the second most frequent food source for *E. coli* O157:H7 outbreaks during 1982–2002 *(34)*. In the 2009–2013, CDC National Outbreak Reporting System *(7)*, 29% of the outbreaks were attributed to produce — fruits, vegetables, grains and sprouts. It is not always clear from some of these outbreaks what could be specifically attributed to on-farm contamination versus home or retail/foodservice. However, 2012 CDC surveillance data reflected 583 documented illnesses from seeded vegetables (e.g., cucumbers, tomatoes) and row crops (e.g., leafy greens) versus the 1,504 illnesses reported in 2015 *(8, 9)* that likely occurred prior to retail or consumer preparation. Furthermore, with no action, the FDA estimated that the over 900,000 domestic foodborne illness cases attributed to produce that would be covered by the rule would not be expected to decrease substantially *(46)*. Foodborne illness outbreak investigations provided evidence to support the development of risk-based preventive strategies to minimize food safety risks and regulatory oversight for implementation, using GAP on-farm food safety strategies as the foundation.

The Food Safety Modernization Act (FSMA) was signed into law in 2011 *(45)* and directed the FDA to enact 7 food safety rules. One of these, the Produce Safety Rule (PSR), mandated a federal standard for the growing, harvesting, packing and holding of produce for human consumption *(45)*. The PSR specifically identified the Produce Safety Alliance (PSA) developed training curriculum (or equivalent) as the required training that all farmers would need to comply with the FSMA-PSR. This training, aligned with the PSR requirements, has the principles of Good Agricultural Practices from growing to packing as its foundation. Prior to FSMA, growers implemented voluntary GAP programs, which were administered by state agencies, USDA, and/or private auditing firms and were usually mandated by buyer requirements. There are state programs (e.g., RI, MA), and nationally recognized programs (Harmonized, USDA GAP/GHP).

Because small local and regional food systems were most challenged by food safety and food safety regulation, Congress included a Qualified Exemption (QE) for small growers in the Act. Growers who generate between $25,000 and $500,000 in total annual food sales and sell the majority (> 50%) of their produce to qualified end users — direct to consumers, or to retail, restaurants, supermarkets that are within the same state or within 275 miles of their farm — qualify for the exemption. Additionally, growers with produce sales less than $25,000 would not be covered by the PSR *(45)*. The U.S. Census of Agriculture estimates that 96% of fruit and vegetable farms in the New England (NE) region have gross sales under the qualified exemption threshold of $500,000 *(43)*, thereby potentially meeting the PSR requirement for QE and not being required to attend PSA training (or equivalent).

However, buyers can require compliance with the rule and/or an on-farm, third-party audited GAP program. A study of VT growers found that the primary motivation to become GAP certified was buyer requirements (88%), with fewer growers citing the need to assure their customers of the safety of their food (6%) and/or plans for expanding market access (6%) *(1)*. There would appear to be little incentive for "exempt" farmers to learn about and implement produce safety practices unless their buyers require it. However, farmers need to adopt practices that protect consumers. Consumers are aware of issues that shape their produce purchasing decisions *(3)* and they react to outbreaks by reducing their consumption and purchases of the affected commodities, resulting in both immediate and long-term economic losses for the industry *(6, 24)*. One of the factors influencing consumer choices about purchasing local produce is food safety. Many consumers perceive local (and often organic) produce to be safer than non-local, conventional produce *(2, 11, 12, 48)*. Between 2007 and 2012, 25 states saw both the number of farms and the amount of land in farms decrease, while only 10 states, including the 6 New England states, saw both of these numbers increase *(41)*. Between 2002 and 2007, the value of products to consumers sold to consumers by RI farmers alone through direct market channels (e.g., farm stands, Community Supported Agriculture (CSAs), and farmers' markets) grew by 42% *(31)*. In a 2013 survey of market managers across the United States, over 60% indicated that there was an increase in customer traffic and annual sales *(36)*. While market growth appears to have slowed since 2012, direct marketing of farm products through farmers' markets continues to be an important sales outlet nationwide, with a national count of farmers' markets in 2017 at close to 8,700 *(37)*. Direct-to-consumer sales have helped smaller farms maintain economic viability *(12, 20)*. Smaller NE farmers could leverage market share with a specific audience because of the food safety perceptions and anecdotal experiences of consumers, but all farmers need to adopt practices that protect the consumer. However, there have been few studies to assess farmers' knowledge and on-farm implementation of food safety procedures that could lie outside the regulatory framework, and no recent studies have specifically targeted New England farmers.

The majority of NE farms will be either uncovered by, or exempt from, the current PSR regulation; however, the adoption of science-based, scale-appropriate on-farm food safety prevention strategies to minimize risks is important for all farmers, regardless of size and regulatory mandate. Educators have little information regarding the on-farm

food safety knowledge, implementation of farm food safety strategies or attitudes of this farming community. Scale-appropriate, risk-based strategies to address on-farm food safety issues would vary because of differences in farm size, production practices, diversity of produce grown, and access to resources and marketing practices among growers. Educators need a better understanding of the learning and information needs of smaller farmers so that they can deliver scale-appropriate best-practices training, using the PSA and/or other GAP curricula as the foundation. The research presented in this article is part of a larger USDA funded AFRI project to design supports for the adoption of scale-appropriate Good Agricultural Practices that will help increase access to local and regional markets for small and medium-size New England farmers. The goal of this project was to conduct a survey of small- and medium-scale farmers in the NE region to assess their current knowledge of and attitudes toward on-farm food safety practices and their economic readiness to implement on-farm food safety strategies, as well as to present the results regarding knowledge, attitude and training. A detailed economic readiness assessment will be presented in a subsequent publication.

MATERIALS AND METHODS

Sampling and data collection

Survey development, review and implementation followed the protocol utilized by Pivarnik and research colleagues for mailed and electronic needs assessments for a variety of target audiences *(14, 15, 16, 26, 27, 28, 29)*. Survey development included both online (using SurveyMonkey®) and paper/mail formats to reach small- and medium-sized fruit and vegetable growers throughout New England (CT, MA, ME, NH, RI, VT). Two survey formats were used based on the preferred method of solicitation by state project directors. The paper/mail survey, for which state project directors identified a representative sample of the target audience and providing address labels (minimum of 250 for each state), was implemented in CT (n = 251), MA (n = 250), NH (n = 388), and RI (n = 250). For the online survey, implemented in ME (n = 286) and VT (n = ~550), state project directors administered the online survey by sending an email containing the survey link to appropriate LISTSERVs. The state grower LISTSERV was used in ME and industry-associated LISTSERVs for tree growers and fruit/vegetable growers were used in VT. The survey was launched in March 2016 and data were collected through the end of April 2016. The mailed survey was administered according to one of the strategies outlined by the Dillman Total Design Method *(32)*. This protocol included mailing a survey announcement postcard about 2 weeks prior to the paper/mail survey administration. The survey, along with a self-addressed stamped envelope, was mailed about a week later. The questionnaire contained a letter explaining the project and survey. A second survey reminder postcard was mailed about 2 weeks later. An email reminder was sent to the target audiences in ME and VT, utilizing the LISTSERVs. In an effort to maximize response, an incentive/gift card ($100) was offered to 20 farmers via a lottery-type drawing for surveys returned by the April 22, 2016 deadline. Respondents wishing to enter the lottery provided their name and contact information on a form accompanying the mail-in survey, which was immediately removed from the survey packet upon receipt, to protect respondent anonymity. Respondents completing the online survey were provided a link that redirected them to another page, separate from the online survey, where they could enter their contact information to protect their anonymity. Respondent contact information was consecutively numbered in the order received (i.e., 1, 2, 3, etc.). Using Microsoft Excel (2010), random numbers were generated for 20 respondents to receive the incentive/gift card. Every state had representation in the pool of lottery recipients. Of the 1975 farmer contacts made via mail and email, 50 mailed surveys were returned or had inadequate addresses. Although the total number of contacts for survey distribution appeared to be 1925, this number may not be completely accurate if the United States Postal Service did not return all undeliverable survey packets. However, based on the responses received, there was an approximate return rate of 16%.

Questionnaire

The survey targeted small- and medium-size farms, based on annual Gross Cash Farm Income (GCFI) as defined by the USDA Economic Research Service and National Agricultural Statistics Service *(39)*: small (< $350,000) and medium ($350,000–$999,999). Large farms ($1,000,000+) were not included. The survey instructed those indicating that they were large farms that they did not fit into the study group and were not to continue. The survey included 4 sections: background information; knowledge about on-farm food safety practices; attitudes toward on-farm food safety; and implementation economic readiness for an on-farm food safety GAP program. As stated previously, knowledge, training, and attitude data will be presented in this manuscript and the detailed economic readiness results and analysis will be reported in a subsequent publication.

The background section was designed to gather demographic information including farm location (state), farm size (acreage), crops grown, food safety training (i.e., Good Agricultural Practices), and distribution of products. Finally, farmers were given the definition of PSR-qualified exemptions and were asked to self-assess which category they fit into: not covered by the PSR, met the requirements for qualified exemption, covered, or not sure. Respondents were asked to check all that applied for specific questions that had, potentially, more than one answer. Forty-four *(44)* knowledge questions were designed to assess baseline knowledge of general food safety and on-farm food safety principles.

The response for knowledge questions was "agree," "disagree," or "don't know." For purposes of statistical assessment, "don't know" reflected a lack of knowledge and was considered an incorrect answer. Subject mastery or proficiency, at 80% correct, has been used previously to evaluate the knowledge base of diverse audiences *(14, 15, 16, 26, 27, 28, 29)*. Knowledge items were grouped into 7 categories: general food safety, water safety, health and hygiene, planting/growing/harvesting, post-harvest, animal and pest control, and recall/traceback. There were 13 attitude statements related to the importance of on-farm food safety, the role of farmers in adopting practices to reduce microbial risk in the products they sell, trust in the safety of the food supply, and perceptions about food safety of locally grown produce and small farms. These statements were rated on a 5-point Likert scale, with 1 = strongly disagree to 5 = strongly agree.

The protocol and questionnaire were approved by the University of Rhode Island Institutional Subjects Review Board. Prior to implementation, the survey items were reviewed by twelve experts for content validity and clarity. Experts were solicited from Land Grant Cooperative Extension programs, academic institutions, and the project advisory panel. The questionnaires were revised prior to distribution based on their recommendations.

Data analysis

Data were analyzed using the SPSS statistical program (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Analysis of descriptive statistics (e.g., frequencies, percents, means, ranges, and standard deviations), one-way ANOVA followed by the Scheffe's post hoc procedure, and *t*-tests were performed to determine statistical significance between means. Chi-square tests were performed when the relationships between variables were examined for observed versus expected frequencies. Reliability was examined using Cronbach's alpha measure of internal consistency. Significant findings were reported at $P < .05$, as noted.

RESULTS AND DISCUSSION

Database results included responses on both partial, when appropriate, and completed surveys. *Table 1* shows key background characteristics of small- (n = 254) and medium-sized (n = 47) grower respondents, with distribution of respondents as follows: CT (21%), ME (9%), MA (16%), NH (31%), RI (12%), and VT (9%). While VT and ME project directors felt that electronic survey delivery was best to reach the targeted audience, the lower numbers of respondents in VT and ME could be due to electronic survey administration versus mailed survey for the other states. Bihn and others *(4)* also reported a higher return rate of paper than of electronic survey questionnaires from fresh produce growers. Of the respondents, 45% indicated they use up to 5 acres for produce production and 25% and 29% indicated they use 6–20 acres and > 20 acres, respectively. While 15% indicated they were the only employee, 43% indicated they had 2–4 employees and 24% indicated 5–10 employees. These data compared favorably to the U.S. Census of Agriculture data, which indicate that the majority (almost 70%) of New England farms had 4 or fewer workers, with 28% of those claiming one worker, and almost 60% of New England farms harvest less than 20 acres *(40)*. Additionally, the distribution of survey respondents compared favorably to the U.S. Census data for the distribution of fruit and vegetable farms in NE: 49% versus 53%, respectively, for the northern NE states (NH, ME, VT) and 49% vs 48% from the southern tier (CT, MA, RI) *(40)*.

A diversity of fruits and vegetables many considered high risk were grown by NE farmers *(45)*. Fruits grown by respondents included berries (83%), apples and/or pears (52%), melons (33%) and stone fruit (33%) (data not shown). The types of vegetables grown included fruit and vegetables (90%), leafy greens (77%), root vegetables (73%), brassica vegetables (70%), herbs (70%), legumes (68%), bulbs (62%), tuber vegetables (54%), stalk vegetables (51%), and sweet corn (48%) (data not shown). Smaller farms tend to be more diversified with respect to production and management strategies, while larger farms tend to be more specialized *(38)*.

As expected, the overwhelming majority of the respondents would be considered either QE or not covered by the PSR. Approximately half (51%) of the respondents indicated they met the requirements for the PSR qualified exemption, 36% indicated they had annual produce sales less than $25,000 and were not covered, and only 8% indicated they were covered under the Produce Safety Rule *(Table 1)*. While some vegetables are not covered by the Produce Safety Rule because they are rarely consumed raw (e.g., potatoes) *(45)*, farmer survey respondents were not asked to distinguish between covered and uncovered produce that they grew.

Even though the vast majority of respondents would be exempt or not covered (87%), when queried if they were willing to invest in on-farm food safety-related practices, 46% of respondents still indicated that they were willing to invest, and 50% indicated it would depend on the cost. When asked if they were able to invest in such practices, the majority (64%) pointed to costs as the determining factor. A study in Oregon found similar results for small- and medium-size farms regarding GAP certification; some growers were making investments and operational changes irrespective of requirements for certification *(30)*.

Table 2 illustrates food safety training and on-farm implementation of practices by the survey participants. While the majority of respondents, regardless of farm size, indicated they attended a GAP or equivalent food safety training, 54% and 89% for small- and medium-sized farms, respectively, statistical analysis indicated a significant

TABLE 1. Background information of New England small- and medium-grower respondents (n = 301)

	Frequency	%
Farm Size[a] (n = 301)		
Small (<$350,000)	254	84
Medium ($350,000–$999,999)	47	16
State Where Farm is Located (n = 301)		
Connecticut	62	21
Maine	28	9
Massachusetts	49	16
New Hampshire	93	31
Rhode Island	37	12
Vermont	28	9
State not indicated	4	1
Acres Used for Produce Production (n = 300)		
Up to 5 acres	136	45
6–20 acres	76	25
21–50 acres	49	16
51–80 acres	19	6
81 and over acres	20	7
Number of Employees[b] (n = 301)		
1	44	15
2–4	128	43
5–10	73	24
11–20	36	12
More than 20	20	7
Type of Produce Grown (n = 300)		
Fruits	51	17
Vegetables/herbs	78	26
Both fruits and vegetables/herbs	167	56
Other[c]	4	1
FSMA Produce Safety Rule Exemption Category (n = 301)		
Total annual produce sales of $25,000 or less	108	36
Meet the requirements for FSMA qualified exemptions[d]	153	51
Do not qualify for FSMA exemptions	24	8
Unsure	13	4
I prefer not to answer this question	3	1
Willing to invest in on-farm food safety related practices (n = 295)		
Yes	137	46
No	12	4
It depends on cost	146	50

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TABLE 1. Background information of New England small- and medium-grower respondents (n = 301) (cont.)

	Frequency	%
Financial ability to invest in on-farm food safety related practices (n = 296)		
Yes	71	24
No	35	12
It depends on cost	190	64

[a]Farm size based on annual Gross Cash Farm Income (GCFI) categories, established by the USDA Economic Research Service and National Agricultural Statistics Service, 2015 (data as of January 2017).

[b]Includes themselves, family members, full-time or part-time and seasonal workers.

[c]"Other" listed: maple syrup, meat and fiber, small grains, vegetable and herb seedlings.

[d]Total food sales of < $500,000 (over a 3-year average) and the majority of food is sold directly to qualified end users in-state or less than 275 miles away from the farm.

Note: The specific number of respondents (n) is shown with individual questions to indicate where some respondents didn't answer the question.

relationship between such attendance and farm size, in that small farms had lower attendance than expected and medium farms had higher participation than expected. Even though GAP audit participation was low, the majority of farmers (>70% for both farm size categories) indicated implementing on-farm food safety practices. Evaluation of GAP-trained farmers in Pennsylvania *(22)* also found that few respondents (20%) intended to seek third-party audit certification for their farms. Food safety training and implementation of on-farm food safety practices were compared among the FSMA exemption categories. As would be expected, for those respondents reporting that they do not qualify for the PSR qualified exemption, 87% attended a GAP or equivalent food safety training, 67% have participated in a GAP audit and 100% are implementing on-farm food safety practices. A surprising outcome of the survey was the high number of respondents who were either not covered by or met the requirements for qualified exemptions from the Produce Safety Rule, but who had received GAP or equivalent food safety training, 48% and 60%, respectively. In addition, the majority of these farms were implementing on-farm food safety strategies, 66% and 74%, respectively *(Table 2)*. Overall, a majority of survey respondents had received food safety training and were implementing on-farm food safety practices, regardless of their FSMA exemption category.

The majority of farmers (74%) indicated that they packed produce in a packing facility — either temporary or permanent — and were washing their produce (72%) *(Table 3)*. A small pool of respondents, 5%, reported packing produce in their home kitchen, where cross-contamination could be particularly high if cleaning and sanitizing is not adequate because of family use. Postharvest handling of produce in a packing facility can be a significant source of pathogen risk, particularly *Listeria monocytogenes*, in the absence of good knowledge of hygienic practices and proper use of postharvest water *(10)*. Interest in local and regional food as a way to connect with food and community has stimulated growth in direct marketing opportunities *(20)*. The majority of survey respondents sold their products directly to consumers (DTC sales) and retail outlets, via farm stands (72%), farmers' markets (44%), retail/grocery outlets (44%), restaurants (36%), CSA (32%), and pick-your-own arrangements (31%) *(Table 3)*. This would be expected of farms that were either not covered or met the qualifications for exemption *(45)*. Donation was higher than expected (35%), and sales to wholesalers/distributors was 28% *(Table 3)*. All six NE states were reported to be among the 10 states that had the largest percentage of farms selling their products to qualified end users (i.e., grocery stores, restaurants, schools, and hospitals) *(42)*. Nationally, small farms have been reported to account for 58% of DTC sales *(43)*. Market channels may influence the implementation of GAPs among small- and medium-scale produce growers, who may choose sales to qualified end users (e.g., farmers' markets, roadside stands, restaurants, etc.) that may be less likely to require GAP certification or other food safety requirements *(21, 30, 35)*.

Tables 4 and 5 illustrate the rank ordering of the knowledge questions from high to low by mean and content mean category scores, respectively. Total knowledge had an alpha reliability of 0.83, indicating that the data were reliable measures of knowledge. The questions were grouped into content categories

TABLE 2. Respondents' attendance in GAP (or equivalent) training, participation in a GAP audit, and implementation of on-farm food safety practices, separated by farm size and FSMA exemption categories

	Percent (%) of Respondents											
	Attended a GAP (or equivalent) Food Safety Training[a]				Participated in a GAP Audit[b]				Implemented On-farm Food Safety Practices[c]			
		Yes	No	Considering		Yes	No	Considering		Yes	No	Considering
Farm Size												
Small (<$350,000)	**n = 250**	54	36	10	**n = 248**	16	79	4	**n = 252**	73	17	10
Medium ($350,000–$999,999)	**n = 47**	89	4	6	**n = 47**	38	55	6	**n = 47**	81	11	9
FSMA Exemption												
Total annual produce sales ≤ $25,000	**n = 106**	48	42	10	**n = 104**	8	90	2	**n = 107**	66	21	12
Total food sales < $500,000[d]	**n = 152**	60	31	9	**n = 151**	20	75	5	**n = 152**	74	16	9
Do not qualify for FSMA exemptions	**n = 23**	87	9	4	**n = 24**	67	25	8	**n = 24**	100	0	0
I prefer not to answer	**n = 3**	100	0	0	**n = 3**	67	33	0	**n = 3**	100	0	0
Unsure	**n = 13**	85	0	15	**n = 13**	15	69	15	**n = 13**	92	0	8

[a]Respondents indicated their attendance in a Good Agricultural Practices (GAP), Practical Produce Safety, or other on-farm food safety training workshop.

[b]Respondents indicated their participation in a GAP audit conducted by state, USDA, or other third party auditor.

[c]Respondents indicated implementation of on-farm food safety procedures, with or without attendance in a GAP (or equivalent) training or participation in an audit.

[d]Total food sales of < $500,000 (over a 3-year average) and the majority of food is sold directly to qualified end users in-state or less than 275 miles away from the farm.

representing on-farm food safety practices related to general food safety, water safety, health and hygiene, planting/growing/harvesting, post-harvest, animal and pest control, and recall/traceback. The bold-type scores in *Table 4* indicate the percent correct answer for each knowledge item. Water safety (68%), post-harvest handling (74%) and general food safety (74%) scores were the lowest scores for knowledge categories. Only 25 of the 43 (58%) knowledge item scores met the 80% standard of subject mastery or proficiency *(15, 16, 27, 28, 29)*. The mean percent correct scores ranged from 68% to 88% for the different content categories. While the total knowledge score, 77 ± 13%, was below subject proficiency, it was higher than anticipated and could reflect the many years of ongoing GAP-related training in the region.

Certain on-farm practices related to water, manure, and post-harvest handling (personal hygiene and equipment sanitation) have been identified as critical food safety risk areas *(13, 17, 25)* and may be more problematic for small- and medium-sized farms. Assessment of current on-farm food safety practices on small- and medium-sized farms located in Georgia, South Carolina and Virginia highlighted inadequate cleaning and sanitizing of facilities and equipment as practices that could increase produce food safety risks *(13)*. Similar concerns could be ascertained from the results of the present survey, as the respondents had lower

TABLE 3. On-farm post-harvest practices regarding product sale/distribution, packing and washing of produce of New England small- and medium-sized grower respondents

	Frequency	%
Where Sell/Distribute Products (n = 301) (checked all that applied)		
Direct sale to consumers – farm stand	216	72
Direct sale to consumers – farmers' market	131	44
Direct sale to consumers – pick your own	93	31
Direct sale to consumers – Community Supported Agriculture (CSA)	96	32
Direct to restaurants	108	36
Direct to schools	40	13
Direct to state/local/private agencies (universities, correctional facilities, hospitals)	23	8
Direct to retail outlets, grocery stores or other farm stands	131	44
Wholesaler/distributor	84	28
Donate to soup kitchens, pantries or community agencies	105	35
Other[a]	4	1
Location Where Produce is Packed (n = 301) (checked all that applied)		
In the field	91	30
In a packing facility – temporary or permanent	222	74
In home kitchen[b]	14	5
PYO/buyer packages[b]	3	1
Processing facility[b]	2	1
Other[c]	9	3
Produce is Washed (n = 299)		
Yes	215	72
No	84	28

[a] "Other" listed: cider business buys apples, breweries and distilleries, not selling yet, pie company.

[b] These categories were created after examining responses to the "other" category.

[c] "Other" listed: on-farm commercial kitchen, certified kitchen, wash and pack in garage, none, do not pack.

Note: The specific number of respondents (n) is indicated with individual questions to indicate where some respondents didn't answer the question.

knowledge scores regarding post-harvest handling. Jackson et al. *(17)* assessed growers and packers in FL, TX, CA, GA, MI, NY and AZ and found that respondents who were aware of GAPs were significantly more likely to encourage good personal hygiene practices of employees by providing toilet and handwashing facilities, both in the field and in the packinghouse, in addition to being significantly more likely to provide hygiene-specific worker training, than were respondents who were not aware of GAPs. However, growers may not fully appreciate the benefit of adopting GAPs *(17)* because it may be perceived as a financial and time burden *(21, 25, 35)*. This study found that over 50% of small-scale farmer respondents have attended training, have implemented on-farm food safety practices, and are willing to consider investment. Finally, fewer than half (44%) of the survey respondents were aware that outbreaks related to the consumption of raw fruits and vegetables have been increasing. This may be an important piece of information to consider concerning grower decision-making on the adoption of food safety agricultural practices. Parker and others *(25)* found that the selection of food safety prevention strategies being implemented by growers was driven by the farmer's perception of sources of microbial contamination. In addition, two content areas with lower knowledge scores were water safety (68%) and post-harvest handling (74%). It is well established that agricultural water used for production

TABLE 4. Item level knowledge of New England small- and medium-sized grower respondents regarding on-farm food safety agricultural practices within content categories, ranked from high to low percent correct answers (n = 294–301)

	% Response		
Items	Disagree	Agree	Don't Know
General Food Safety Items			
Sources of microbial contamination can come from people, animals and the environment	0	**99**[a]	1
Soil and water can be sources of disease-causing microorganisms that can contaminate produce	2	**96**	2
Organically grown produce is less likely to cause foodborne illness than conventionally grown produce	**76**	11	12
The U.S. Food and Drug Administration (FDA) is the federal agency that regulates produce safety	8	**73**	19
Disease-causing organisms, like *Listeria,* can grow at refrigerated temperatures	6	**55**	39
Outbreaks associated with the consumption of raw fruits and vegetables have been increasing	19	**44**	37
Water Safety Items			
Flooding can cause the contamination of produce that grows on or near the ground	6	**90**	4
Livestock up-stream from a surface water source used for irrigation is not a risk if it is not adjacent to the farm	**87**	4	9
Backflow prevention devices minimize the risk of contamination of the water supply	3	**81**	16
Drip irrigation is more likely to cause contamination than overhead irrigation	**71**	4	25
Generic *E. coli* is considered the indicator organism for irrigation water safety	11	**52**	37
Well water is generally considered the safest for irrigation because the farmer has control over this water source	**29**	56	15
Health and Hygiene Items			
Proper handwashing is one of the most important ways to prevent transfer of harmful microorganisms to food	2	**98**	<1
If workers have cuts or sores on their hands, clean gloves should be worn when harvesting to protect the fruits and vegetables from microbial contamination	3	**95**	2
Customers of Pick-Your-Own fruits should be aware of hygienic practices (e.g., handwashing) prior to harvesting	3	**91**	6
Workers can eat food while harvesting or packing produce since produce is also a food	**87**	7	6
Workers can smoke in the field since there is no direct contact with the produce	**87**	3	10
Since workers will get dirty during harvesting and packaging, it is not important for them to start the day with clean clothing	**85**	11	4
The only handwashing stations that you can use are ones that are directly plumbed into a municipal water supply with potable/drinkable water	77	13	10
Hand sanitizers are good substitutes for handwashing with soap and water, in the field	**44**	40	16
Planting/Growing/Harvesting Items			
Harvest bins only have to be cleaned at the beginning of the season	**91**	5	4
Raw manure can be added to soil just before planting as long as it is thoroughly mixed into the soil	**84**	8	8
It is ok to harvest a tomato contaminated with bird poop as long as it is wiped off before packing	**83**	8	9

Continued on next page

TABLE 4. Item level knowledge of New England small- and medium-sized grower respondents regarding on-farm food safety agricultural practices within content categories, ranked from high to low percent correct answers (n = 294–301) (cont.)

Items	% Response		
	Disagree	Agree	Don't Know
Planting/Growing/Harvesting Items			
Leafy greens can be a higher risk product because they grow close to the ground	12	77	11
The primary reason for composting manure to the proper temperature is to yield a nutrient rich soil additive	**72**	19	9
Damaged or bruised produce do not have higher risk to cause foodborne illness if the produce is properly washed prior to sale	**72**	11	17
GAP programs do not allow the use of manure in the fields	**57**	9	34
Post-harvest Items			
All chemicals used in a packing house/facility must be properly labeled	1	**97**	2
Trucks used to transport produce can be a source of contamination	1	**95**	4
Leaves, dirt and other debris on a packing house floor do not present a food safety risk	**93**	2	5
A packing house that is completely enclosed poses no food safety risks to produce	**91**	2	7
Post-harvest water applications to produce can be done with well water that has not been tested	**85**	5	10
Ice must be treated as a food	1	**80**	19
Pathogenic microorganisms can be found on all surfaces in a packing house	9	**79**	12
A sanitizer added to produce wash water can help reduce the microbial load	6	**75**	19
Floor drains are often the source of *Listeria* bacteria	5	**35**	60
The proper sequence for a cleaning and sanitizing program is to wipe away debris, then sanitize and air dry	**10**	68	22
Animal and Pest Control Items			
Barn birds are not a pest risk because the nests are in the ceiling rafters	**96**	2	2
Old or unused equipment stored near a packing house should be moved since it could harbor pests	5	**88**	7
Removal of cull piles and crop residue are important in wildlife management	3	**85**	12
Manure from any domestic or wild animal can carry human pathogens	5	**74**	21
Recall/Traceback Items			
An effective traceback program can trace produce back to the harvest date/location and forward to the customer	3	**88**	9
Due to the perishability of many fruits and vegetables, a traceback program for produce is not important to implement	**87**	2	11

[a]Bolded numbers indicate correct response.

(e.g., the source, quality, application method, and timing) and in post-harvest practices (e.g., wash water) can impact produce safety. While the majority (76%) of respondents indicated they wash produce, specific information regarding how the produce is washed was not gathered (e.g., whether sanitizers are used). It appears that educators of this target audience would need to place greater emphasis on the role of produce in foodborne outbreaks and its relationship to agricultural water application and post-harvest handling.

Table 6 shows a comparison of percent total knowledge scores by specific respondent background categories. There were no significant differences in knowledge based

TABLE 5. Level of knowledge of New England small- and medium-sized grower respondents regarding on-farm food safety agricultural practices for total and specific content categories (n = 294–301)

Knowledge Content Categories	Mean % correct ± standard deviation (alpha reliability[a])	Question range (%) correct	Survey questions below mastery[b]	Total questions
Total	77 ± 13 (.83)	10 to 99	42%	43
General Food Safety	74 ± 19	44 to 99	67%	6
Water Safety	68 ± 21	29 to 90	50%	6
Health and Hygiene	83 ± 16	44 to 98	25%	8
Planting/Growing/Harvesting	77 ± 21	57 to 91	57%	7
Post-harvest	74 ± 16	10 to 97	40%	10
Animal and Pest Control	86 ± 20	74 to 97	25%	4
Recall/Traceback	88 ± 29	87 to 88	0%	2

[a]Alpha reliability was calculated on the complete set of data.

[b]Subject mastery = 80%.

on farm size, although respondents from medium-size farm operations met the 80% subject mastery. Food safety training and implementation of on-farm food safety practices impacted knowledge, as evidenced by the significantly ($P < 0.05$) higher scores among respondents who have received training (80% vs. 73%) and those who reported implementing on-farm food safety practices (79% vs. 71%). Respondents who identified themselves as needing to comply with the Produce Safety Rule had higher or significantly ($P < 0.05$) higher knowledge than respondents who meet the requirements for FSMA qualified exemptions and those who were not covered by the rule, for whom knowledge scores were 83% vs. 78% and 75%, respectively. Finally, respondents who indicated they were economically willing and able to invest in on-farm food safety practices had significantly ($P < 0.05$) more knowledge than those who did not, 81% vs. 67% and 82% vs. 73%, respectively. There were no differences in knowledge by farm location (state), farm size (acres), or the number of employees (data not shown). There were no differences in knowledge for those respondents growing high-risk commodities, such as melons, leafy greens, and fruit vegetables (data not shown).

Table 7 shows attitude scores of respondents regarding on-farm food safety agricultural practices, with an overall score of 3.5 ± 0.5 and an alpha reliability of 0.68. Byrd-Bredbenner and others *(5)* found that a Cronbach alpha coefficient of internal consistency of even slightly lower than 0.70 was found to indicate reliability. There were 13 questions reflecting 4 content category areas: on-farm food safety, trust, perception of locally grown food, and perception of customers. The first category probed how the respondents felt about the importance of on-farm food safety (4.0 ± 0.9). The highest scores reflected the importance for their employees to know their role in keeping food safe (4.6 ± 0.6) and for farmers to address produce safety (4.4 ± 0.7). As indicated by the findings of Jackson et al. *(17)*, who reported that increased GAP awareness resulted in higher implementation and worker training, the degree of GAP or equivalent food safety training could have resulted in the overwhelmingly positive attitude toward on-farm food safety. However, respondents appeared to have a more negative attitude about trusting others (i.e., third party auditors, retailers, and government) to keep the food supply safe (2.4 ± 0.8). A lack of trust in regulating agencies by small and medium-scale growers has been recognized as a contributing barrier to adopting food safety standards *(48)*. Participant attitudes regarding "smaller is safer" was "neutral," or lower than anticipated (3.1 ± 0.9), reflecting the opinion that locally purchased or grown produce is of equal safety to produce from a grocery store or larger farm. This finding could be in line with the high belief that even as a small- or medium-sized farm, on-farm food safety was important. The fourth category highlighted respondents' perception that their customers value food safety (4.4 ± 0.8) and trust farmers to grow safe produce (4.2 ± 0.8). However, respondents were less confident regarding their customers' willingness to pay more for produce grown on farms with food safety programs (3.0 ± 0.9), which could affect willingness to implement and invest in on-farm food safety practices. Inter-item correlation among the four attitudinal categories — importance of on-

TABLE 6. Comparison of total knowledge of New England grower respondents on-farm food safety agricultural practices, separated by farm size, training and implementation, FSMA exemption categories

Categories	Total Knowledge Score (Mean ± Standard Deviation)	
Farm Size[a]		
Small (< $350,000)	n = 251–254	77 ± 13
Medium ($350,000–$999,999)	n = 45–47	80 ± 13
Attended a GAP (or equivalent) Food Safety Training		
Yes	n = 174–176	80 ± 12[1]
No	n = 91–93	73 ± 13[2]
Considering	n = 27–28	72 ± 12[2]
Participated in a GAP[b] Audit		
Yes	n = 57–58	83 ± 9[1]
No	n = 219–223	76 ± 13[2]
Considering	n = 14	78 ± 8[1,2]
Implemented On-farm Food Safety Practices[c]		
Yes	n = 221–223	79 ± 12[1]
No	n = 44–48	71 ± 13[2]
Considering	n = 28	71 ± 15[2]
FSMA Produce Safety Rule Exemption Categories		
Total annual produce sales ≤ $25,000	n = 106–108	75 ± 14[1]
Meet the requirements for FSMA qualified exemptions[d]	n = 150–153	78 ± 12[1,2]
Do not qualify for exemptions	n = 24	83 ± 10[2]
Investment in On-farm Food Safety Practices		
Willing to Invest		
Yes	n = 133–137	81 ± 11[1]
No	n = 12	67 ± 22[2]
Maybe, it depends on cost	n = 145–146	74 ± 13[2]
Able to Invest		
Yes	n = 69–71	82 ± 10[1]
No	n = 35	73 ± 16[2]
Maybe, it depends on cost	n = 188–190	76 ± 13[2]

[a]Farm size based on annual USDA ERS Gross Cash Farm Income (GCFI) categories.

[b]Respondents' participation in a GAP audit conducted by state, USDA, or other third party auditor.

[c]Respondents' implementation of on-farm food safety procedures, with or without attendance in a GAP or equivalent training or on-farm audit.

[d]Total food sales of < $500,000 (over a 3-year average) and the majority of food sold directly to qualified end users in-state or within less than 275 miles from the farm.

[1,2]Different numbers indicate significant differences ($P < .05$) between total knowledge scores within categories.

TABLE 7. Attitude of small- and medium-sized New England growers regarding on-farm food safety agricultural practices and perception (n = 294–296)

Items	Content Category	Average Score[a] ± Standard Deviation
It is important for my employees to know their role in keeping food safe		4.6 ± 0.6
I believe produce safety is an important issue that farmers should address		4.4 ± 0.7
I believe that all farmers should follow Good Agricultural Practices (GAP)		3.8 ± 1.1
I believe that regulations are important to ensure on-farm food safety practices		3.5 ± 1.1
On-farm food safety practices are too expensive to implement		3.5 ± 1.1
	On-farm Food Safety: 4.0 ± 0.9	
I trust retailers to handle produce safely		2.6 ± 1.0
I trust third party auditors to keep the food supply safe		2.5 ± 1.0
I trust the government to keep the food supply safe		2.2 ± 1.0
	Trust: 2.4 ± 0.8	
Locally grown produce, purchased from a roadside stand or farmers' market, is safer than produce purchased at a grocery store		3.2 ± 1.0
Produce from small produce farms is safer than produce from large farms		2.9 ± 1.0
	Perception of Small/ Local: 3.1 ± 0.9	
Food safety of produce is important to my customers		4.4 ± 0.8
Because my customers know me, they trust that I grow safe fruits and vegetables		4.2 ± 0.8
I think customers would be willing to pay more money for fruits and vegetables produced on farms with food safety programs		3.0 ± 1.2
	Perception of Customer: 3.9 ± 0.9	
	Total Attitude:	3.5 ± 0.5

[a]Average score was calculated from a 5-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither, 4 = Agree, 5 = Strongly Agree.

farm food safety, trusting others, perception that produce from smaller/local farms is safer, and the perception of customers – indicated a very positive attitude toward on-farm food safety and the perception that their customers value on-farm food safety programs, a more neutral attitude regarding the perception that produce from smaller/local farms is safer, and a more negative, or distrust, of government/auditors/ retailers to keep the food supply safe. Total attitude scores among respondents, separated by demographic categories, showed no differences in attitudes with respect to farm size, training, implementation or FSMA exemptions (data not shown). This was in contrast to results reported by others *(30)*, who reported an attitudinal difference associated with net income, such that medium- and larger-scale growers were more supportive than small growers of GAP. Respondents who indicated willingness to invest in on-farm food safety practices had a significantly ($P < 0.05$) higher attitude score than those not willing to invest, 3.6 ± 0.4 vs 3.1 ± 0.8, respectively. Likewise, respondents who are financially able to invest in on-farm food safety practices had a significantly ($P < 0.05$) higher attitude score than those who are not, 3.6 ± 0.4 vs 3.3 ± 0.6, respectively.

Participation in on-farm food safety training and implementation of on-farm food safety practices was high among survey respondents, even though the majority may not come under the full impact of the FSMA PSR. Although subject mastery was less than 80% *(15, 16, 27, 28, 29)*, the mean knowledge score of survey respondents was higher than expected (77 ± 13%). This could be attributed to the ongoing on-farm food safety training

efforts in the NE region over the years, an assumption supported by the positive attitude score of 4.1 ± 0.7 regarding on-farm food safety agricultural practices. While participation in on-farm food safety training has been shown to improve knowledge of and attitudes toward on-farm food safety practices, growers reported that they still lacked confidence in their ability to implement on-farm food safety practices *(35)*, and post-training intent to change may not translate into practice change *(22)*. A better understanding of the challenges that growers face in implementing on-farm food safety practices would enhance outreach efforts *(22, 35)*. The needs of small-scale growers serving smaller direct-to-consumer market venues may differ from the needs of larger growers serving wholesale markets *(13, 19, 25)*. Both education and more personalized attention to the application of best practices has improved implementation of on-farm food safety practices among small- and medium-sized farms *(19, 35)*. Finally, as found in a study of the Pennsylvania farming community *(22)*, on-farm food safety outreach initiatives for small- and medium-size growers also resulted in improvements of GAP knowledge and attitudes and the motivation to implement on-farm food safety practices.

CONCLUSIONS/RECOMMENDATIONS

The majority of New England growers had more knowledge of Good Agricultural Practices than expected. The long-standing ongoing training efforts in the NE region could account for the knowledge and belief that on-farm food safety is a farmer's responsibility. The positive attitude towards on-farm food safety practices indicated that small- and medium-sized NE farmers are receptive to food safety outreach. Risk-based, scale-appropriate strategies and tools to support the adoption of on-farm food safety practices may encourage PSR-exempt growers to implement and expand on-farm food safety strategies. Using the existing GAP and/or PSA curriculum as the foundation, scale-appropriate teaching strategies and best practices can be designed to help such growers meet their goals and increase their access to local and regional markets.

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