

## On-Farm Produce Safety: A Review of Needs Assessments of Small- and Medium-Sized Growers in the United States

### ABSTRACT

With the voluntary adoption of good agricultural practices and the regulatory requirements of the Food Safety Modernization Act, produce growers have a continued need for educational programming. To understand these needs, the administration of produce safety needs assessments has increased. A summary of all available needs assessment research is needed to inform educational programming that addresses the complexity and range of produce safety requirements based on farm size and market access. This semisystematic review of 34 needs assessments from 2005 to 2020 summarized known produce safety needs and how those were influenced by a variety of factors among small- and medium-sized producers in the United States. Although growers face the needs of training, knowledge, time, capital, and mindset, the factors of farm size, region, market, and farm type influence how growers prioritize and are impacted by these needs. Therefore, educational programming cannot take a one-size-fits-all approach. It is essential to tailor education to the specific needs

of producers while considering the various ways in which those needs can differ among specific groups of stakeholders because of influencing factors.

### INTRODUCTION

The 1998 U.S. Food and Drug Administration (FDA) (37) “Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables” outlined guidance for growers on how to reduce food safety risks on the farm and served as the basis for good agriculture practices (GAPs). Full GAPs compliance or adoption of some practices is voluntary but is often required for various types of market access (4, 20). In 2011, the passage of the Food Safety Modernization Act (FSMA) “Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption,” commonly referred to as the Produce Safety Rule (PSR), established the first federal regulation relating to the growing, harvesting, packing, and holding of produce for human consumption (39). Growers of all farm sizes are likely subject to food safety requirements because of either increasing market access requirements (20) or coverage under the FSMA PSR (39).

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Adopting produce safety practices to meet market access or regulatory requirements is a complex process for growers due to a mix of factors, including requirements of various state, federal, and grower association audits that differ from regulatory inspections; the lack of FSMA PSR guidance; unfinished relevant scientific research; sections of the FSMA PSR that are under review or reserved; and the wide diversity of size, scale, crops, market channels, and other operational characteristics of the grower community (4). Therefore, the educational needs of growers also are complex, and a continued and evolving need for educational programming is evident to increase growers' produce safety knowledge, assess and reduce on-farm produce safety risks, and meet market access and/or regulatory requirements by passing an audit and/or inspection.

A needs assessment tool is designed to collect feedback to identify needs and understand how to respond to those needs (11). The use of needs assessments is common and increasing agricultural extension and other educational personnel (11). With growing requirements for market access and new regulation, the administration of needs assessments to clarify produce safety needs among growers has increased over the last 20 years. Although needs assessments are important tools for identifying areas of need and promoting effective program planning, they are also very time-consuming to create and administer, can be limited in scope or audience, and may not yield easy solutions because the needs identified are complex (11). In one example, a needs assessment alone was insufficient to understand the complex needs related to local food systems (11). To develop sufficient educational programming, the additional elements of community participation and collaboration were essential to the needs assessment process (11). For produce safety programs, educational personnel have relied on individual needs assessments to inform programming because no systematic literature review has been conducted covering all needs assessments. As a result, the published literature lacks a full accounting of available research on the produce safety needs of growers. The attendees of the 2017 Northeast Center to Advance Food Safety (NECAFS) Annual Conference (Boston, MA) articulated the need to conduct a semisystematic literature review. The goal of this holistic review was to generate findings that covered the complexity of the issues and identified gaps in the literature to inform produce safety educational programming and future needs assessments and research.

Our semisystematic literature review synthesized the data from 34 published produce safety needs assessments and answered a clearly defined primary research question to identify known produce safety needs among small- and medium-sized producers in the United States. The review focused on small- and medium-sized producers because NECAFS work is funded through the U.S. Department of Agriculture (USDA) Food Safety Outreach Program, whose objective in part is to develop and implement food safety training, edu-

cation, extension, outreach, and technical assistance projects that address the needs of owners and operators of small- to medium-sized farms. This semisystematic review provides evidence-based results and recommendations to inform educational programming development specifically for small- and medium-sized produce growers.

## MATERIALS AND METHODS

We followed a semisystematic review process described by Snyder (33) to provide a comprehensive overview and analysis of current published needs assessments on the topic of produce safety and the needs of small- and medium-sized produce growers.

### Define the research question

To build the research question, a group of three agricultural extension personnel (the review team) first determined the target population (small- and medium-sized produce growers and small and very small processors), study area (the northeast United States), type of literature to be reviewed (unpublished and published needs assessments), and outcomes to be measured (understanding needs associated with produce safety and preventive controls for human food). Based on these criteria, keyword search terms were determined (see *Appendix 1* or full list of keywords).

The review team conducted an initial search based on these criteria to assess the research landscape. This early work allowed the review team to develop a clearly defined research question that was not too broad or too narrow. Studies found during this initial search filtered generally into four broad categories: (i) needs identified through assessment when looking at produce safety among producers in the United States, (ii) gaps in knowledge or practice and remaining needs of the target population, (iii) successes and challenges relative to educational and direct technical assistance delivery, and (iv) food safety practice improvement on U.S. farms due to educational programming.

Based on the categories of research available, the review team developed the project research question: "What are the known produce safety needs of small- and medium-sized produce growers in the United States?" This process revealed that limiting the geographic area of review to the Northeast region would be too narrow because few studies were specific to this region. Terms related to small and very small processors and preventive controls for human food were removed from the review because the search resulted in only one needs assessment of this target population. This initial search and research question development process was presented for discussion to an eight-person group of produce safety educators via a conference call. The group confirmed the approach and research question and provided feedback.

## Literature search

The research database search strategy was developed in collaboration with research library team members. The review team also requested any unpublished needs assessment data from partners through direct or referred one-on-one requests and through a NECAFS newsletter. Keyword search terms were revised based on the primary research question (see [Appendix 2](#) for full list of revised keywords).

Searching was completed within the AGRICOLA database, which is produced by the USDA National Agricultural Library and indexes agricultural literature. Keywords were entered with phrases in quotations, connected with the advanced search functions “OR,” “Any field,” and “contains.” The search was limited to journal articles within the United States that were written in English. The References Cited sections of identified articles were examined to find additional relevant studies. All studies were stored on Mendeley Data (<https://data.mendeley.com/>) and an Excel sheet (Microsoft, Redmond, WA) with search log notes and citations. Separate tabs were maintained for published and unpublished data.

## Determining eligibility criteria

The review team developed data inclusion and exclusion criteria based on the primary research question, and the included data (i) assessed grower needs stemming from either GAPs and/or the FSMA PSR, (ii) were collected through a needs assessment, (iii) were published in a written report in a peer-reviewed journal or by a university or government agency, and (iv) were specific to small- or medium-sized growers.

The review team defined “needs assessments” to be any tool administered to members of the produce safety community that collected feedback and articulated produce safety needs (i.e., pre- and posttests, course evaluation, survey, and needs assessment). This definition was used because the wide variation in the design of the needs assessments, including mailed or online surveys, phone interviews, in-person and on-farm visits, pre- and posttests for educational programs, and knowledge tests. Increased nuance and complexities were revealed when using this more broadly defined needs assessment. In Minnesota, Hamilton et al. (12) found that revisiting the same respondents from a prior mailed survey (14) to conduct on-farm interviews with open-ended questions revealed inaccuracies and misrepresentation when growers had originally been asked to self-report. Other studies that included an initial mailed survey (27) were supplemented rather than invalidated by follow-up in-depth interviews (28). Lewis Ivey et al. (17) noted the efficacy of including survey questions about the demographics and current produce safety practices of respondents and the attitudes and perceptions surrounding their decision-making processes. The review team determined that all results that included any data informed by small- or medium-size growers would

be included. Because the studies included a range of audiences (buyers, consumers, gardeners, food safety experts, and growers) and farm sizes, the reported data could not be separated, so the results were included as presented by the original authors.

Exclusion criteria for rejection of data were (i) collected before 2005, (ii) unpublished, and (iii) did not include small- or medium-sized growers. Data collected before 2005 were omitted to ensure timeliness and relevance to the current issues. Unpublished data were omitted because much of the data were in raw form, still requiring analysis, and it was not possible or appropriate to analyze data from other investigators. Studies presenting data from only large growers also were omitted.

## Data screening, extraction, and analysis

After the search was completed and all studies that met the inclusion criteria were identified, the studies were screened for relevance by reading their titles, abstracts, and introductions. When the study was considered relevant, the full report was read and compared against the inclusion and exclusion criteria. All remaining studies were determined to be relevant and included in the analysis. The eligibility determination flow chart is shown in [Figure 1](#).

A descriptive analysis method was followed, and all studies deemed eligible were described, and the results were synthesized and interpreted. Many elements of the needs assessments reviewed varied, including study design, geographic scale (county, state, multistate, or nation), produce safety topic, and complexity. This semisystematic literature review integrated research conducted through different approaches by different researchers describing the contrasting and complimentary ways the topic of food safety needs has been studied and revealed relevant and influencing factors in the literature. An understanding of this complexity will allow the reader to make informed educational decisions through contextualized understanding of growers’ needs.

## RESULTS AND DISCUSSION

The review included 34 published studies that met our search criteria, and the data from these studies were extracted and summarized ([Table 1](#)). We learned that extensive work has been done since 2005 to identify the needs of growers who are working to meet produce safety standards.

The following discussion identifies the key produce safety needs of small- and medium-sized producers including knowledge, training, capital, time, and mindset. Although the studies were primarily focused on these needs, the types of data collected across the individual needs assessments provided connectivity and understanding of external (non-produce safety) influencing factors such as region, farm size, farm type, and market. In this section, we present the needs identified and conclude with the analysis of how these needs are influenced by external factors.

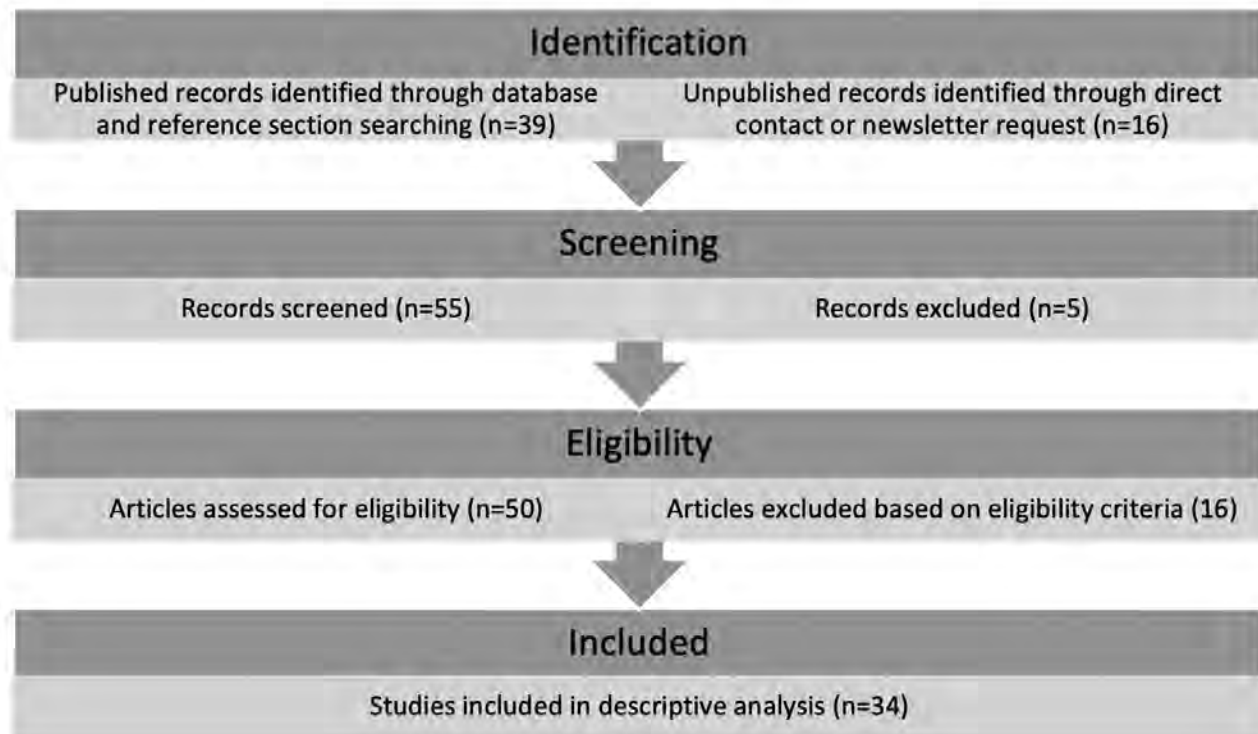


Figure 1. Flowchart of study eligibility determination.

#### Key produce safety need identified: knowledge

With shifting food safety regulations, produce growers require new and continuous knowledge transfer. Growers acknowledged many areas in which they needed more information, often beginning with a clearer understanding of the specific regulations that apply to their operation (10, 17, 22). Growers continuously expressed frustration with or misunderstanding of changing food safety practices and regulations and mentioned the difficulty of complying with conflicting regulations (10, 17, 22). Many growers need assistance understanding the PSR or await guidance before making drastic (and costly) changes to their produce safety practices (10, 17, 22). Growers also expressed confusion about which practices were mandatory and which were recommended (10, 21, 22).

Some growers wanted more information on exact pathways and sources of contamination risks (10, 17, 25, 28, 33). A pre-FSMA survey of growers and packers in seven U.S. states revealed that increased produce safety knowledge resulted in improved hygiene practices and worker training (15). Experts highlighted the importance of assessing current food safety knowledge and practices, at times measuring with pre- and posttraining workshop evaluations (23, 24, 27, 33). Although many of the needs assessments addressed a knowledge deficit for growers, lack of information was clearly not the only barrier to compliance with produce safety standards (22).

#### Key produce safety need identified: training

Along with appropriate knowledge and accurate information about food safety practices, small- to medium-sized produce growers also identified a need for specific technical training (7, 9, 25, 36). In a study of almost 300 New England growers, researchers reported that producers needed training in water testing, record keeping, sanitation of containers and surfaces, and worker hygiene (9). Pires et al. (25) found that most growers surveyed (58%) were applying raw manure to their crops, and training on mitigation of pathogen transmission and safe handling and application of biological soil amendments was needed. Other surveys revealed a need for assistance with employee produce safety training (36) or better documentation of worker training (7). Bihn et al. (7) also found that behavior changes and informed decision making increased among growers who attended formal food safety trainings. Training is an important aspect of produce safety compliance for both growers and individuals involved in the distribution and purchase of produce (7). A survey conducted in the southeastern United States revealed that >40% of growers and >60% of farmers' market managers wanted some food safety training and/or educational materials (13).

#### Key produce safety need identified: capital

Many of the surveyed produce growers identified financial constraints as an obstacle to implementing food safety

**TABLE 1. Summary of studies included in semisystematic literature review**

Research objective	Geographic area	Time frame	Method of delivery	Target population	Investigating agency	Number of respondents	Reference
Determined how expenditures on food safety practices required by the Produce Safety Rule (PSR) differ with farm size.	National	2015	Online survey	Produce growers	Cornell University, University of Maryland	394 Growers	Adalja and Lichtenberg, 2017 (1)
Estimated current usage of food safety practices and the likely extent of change required by the PSR among growers falling into the size classes specified by the PSR, among growers self-identifying as sustainable, and among growers of different types of crops.	National	2015	Online survey	Produce growers	Cornell University, University of Maryland	394 Growers	Adalja and Lichtenberg, 2018 (2)
Microbial food safety practices already in place before implementation of the PSR, covering various food safety practices and measured costs.	National	2015, 2016	In person	Produce growers	U.S. Department of Agriculture, Economic Research Service, National Agricultural Statistics Service	4,618 Growers	Astill et al., 2018 (3)
Described the nuanced reasoning behind growers' actions in response to evolving food safety standards in a complex market.	National	2016–2017	In person across 6 groups	Produce growers, food safety supervisors, state departments of agriculture officials, extension educators, trade organization representative; informed by survey data collected for a 2015–2016 survey of U.S. produce growers (3) and a 2016–2017 case study of produce retailers (20)	U.S. Department of Agriculture, Economic Research Service	50 Individuals	Astill et al., 2019 (4)
Explored economic costs of good agricultural practices (GAPs) audits of small and medium-sized farms in Vermont.	Vermont	2011	Online survey and interviews	Produce growers; GAPs certified, GAPs seeking	University of Vermont	79 Growers	Becot et al., 2012 (5)

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**TABLE 1. Summary of studies included in semisystematic literature review (cont.)**

Research objective	Geographic area	Time frame	Method of delivery	Target population	Investigating agency	Number of respondents	Reference
Examined how consumer behavior and attitudes toward organic, small-scale, and locally produced foods can help organic producers understand consumer values that can be used to develop production and marketing approaches that match these values.	Connecticut, New Hampshire, Maine, Massachusetts, Vermont	2002	Focus groups and interviews	Food shoppers	University of Vermont, Tufts University, U.S. Army Natick Research, Development and Engineering Center	20 Shoppers (focus groups), 27 shoppers (interviews)	Berlin et al., 2009 (6)
Determined the food safety practices, knowledge, barriers, and attitudes of food producers considered local.	National	2017	Online survey	Produce growers, processors, packers or aggregators	Cornell University	1,136 Growers; 397 processors; 509 packers, aggregators	Bihn et al., 2019 (7)
Estimated farm-level costs to comply with the PSR by commodity, state, and farm size.	National	2012	Restricted-access data from 2012 census of agriculture	Produce growers	U.S. Department of Agriculture, Economic Research Service	2012 Census of agriculture	Bovay et al., 2018 (8)
Identified and measured the adoption of grower practices in New England related to safe food handling guidelines.	New England	Funding awarded in 2000	Mailed paper survey	Produce growers	University of Massachusetts	297 Growers	Cohen et al., 2005 (9)
Gained an understanding of growers' awareness, knowledge of, and attitude toward GAPs in general and the FDA guide in particular; understood whether, how, and why growers are currently implementing GAPs using the FDA GAPs guide; identified opportunities to facilitate growers' adoption of the FDA GAPs guide.	Florida, California, Arizona, U.S. Midwest (Ohio State University study)	2009; 2007–2008 (Ohio State University study)	Telephone interviews, including results from survey conducted in collaboration with (Ohio State University study).	Produce growers, trainers, auditors, buyers; produce growers (Ohio State University study)	Prepared for FDA by Decision Partners	22 Growers, 19 trainers and auditors, 4 buyers; 12 large- and medium-scale, 20 small-scale, 12 Amish growers (Ohio State University study)	Eggers et al., 2010 (10)

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**TABLE 1. Summary of studies included in semisystematic literature review (cont.)**

Research objective	Geographic area	Time frame	Method of delivery	Target population	Investigating agency	Number of respondents	Reference
Understood barriers to incorporation of GAPs by Minnesota vegetable farmers.	Minnesota	2008	Mailed paper survey followed up by direct observation with an on-farm survey	Produce growers	University of Minnesota	246 Growers (paper survey), 27 growers (on-farm survey)	Hamilton et al., 2015 (12)
Evaluated current food safety practices used by farmers on small- to medium-sized farms and managers of farmers markets in Georgia, Virginia, and South Carolina.	Georgia, Virginia, South Carolina	Funding awarded in 2009	Mailed paper survey, online survey	Produce growers, market managers	University of Georgia, Virginia Polytechnic Institute and State University, Clemson University	226 Growers, 45 market managers	Harrison et al., 2013 (13)
Learned what areas should be emphasized in future educational GAPs trainings in Minnesota.	Minnesota	2008	Mailed paper survey	Produce growers	University of Minnesota	246 Growers	Hultberg et al., 2012 (14)
Assessed grower and packer knowledge of GAPs and of related educational concepts and implementation of changes in health and sanitation practices that may have resulted from growers' GAPs knowledge.	Arizona, California, Florida, Georgia, Michigan, New York, Texas	2004–2005	Mailed paper survey	Produce growers, packers	University of Florida, Cornell University	596 Growers	Jackson et al., 2007 (15)
Studied past behaviors, behavioral intentions, and changes in knowledge resulting from completion of GAPs workshop.	Tennessee	Unknown	Post-GAP workshop paper evaluation followed up by on-farm visit	Produce growers, agricultural extension educators	Tennessee State University	20 Growers, 10 agricultural extension educators (evaluation), 6 growers (on-farm visit)	Kilonzo-Nthenge et al., 2018 (16)
Measured the perspectives, practices, and potential gaps in knowledge regarding fresh produce safety hazards among midwestern U.S. vegetable producers.	Indiana, Kentucky, Michigan, Ohio	2008–2009	Mailed paper survey	Produce growers	The Ohio State University	164 Growers	Lewis Ivey et al., 2012 (17)

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**TABLE 1. Summary of studies included in semisystematic literature review (cont.)**

Research objective	Geographic area	Time frame	Method of delivery	Target population	Investigating agency	Number of respondents	Reference
Investigated the prevalence and cost of produce safety practices required under the proposed PSR for mid-Atlantic growers of leafy greens and tomatoes.	Maryland, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, West Virginia, Vermont	2013	Online survey at educational booth at 2 state grower conferences	Leafy greens and tomato growers	University of Maryland	47 Growers	Lichtenberg and Tselepidakis Page, 2016 (18)
Assessed Maryland and Delaware vegetable producers' understanding and implementation of GAPs.	Delaware, Maryland	2010, 2013	Online survey at 6 commercial grower meetings	Produce growers	University of Maryland, University of Maryland Extension, University of Delaware	313 Growers	Marine et al., 2016 (19)
Examined how growers adapt to evolving food safety requirements.	National	2016–2017	Interviews	Produce buyers	U.S. Department of Agriculture, Economic Research Service	9 Produce buyers	Minor et al., 2019 (20)
Assessed how effective the GAPs training workshops were for program participants.	Pennsylvania	2012	Pre- and posttests at 10 on-farm food safety workshops	Produce growers	Pennsylvania State University	263 Growers	Nayak et al., 2015 (21)
Enhanced education and policy development and improved the microbiological safety of fresh and fresh cut produce through subject expert elicitation.	National	2007–2009	Focus groups, interviews	Food safety experts	The Ohio State University, Ohio Agricultural Research and Development Center, Michigan State University	19 Food safety experts	Parker et al., 2012 (23)
Enhanced the design and implementation of food safety programming based on farm and marketing needs of producers of fresh fruits and vegetables.	National	2007–2009	Focus groups, interviews	Food safety experts	The Ohio State University	19 Food safety experts	Parker et al., 2012 (24)
Examined on-farm food safety across farm scales to determine whether small- and medium-scale growers pose inherently greater risk.	Indiana, Kentucky, Michigan, Ohio	2007–2009	Mailed paper survey informed by 2007–2009 focus groups of food safety experts (24)	Food safety experts, produce growers	University of Vermont, The Ohio State University, Louisiana State University	19 Food safety experts, 32 growers (interviews), 159 growers (survey)	Parker et al., 2016 (22)

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**TABLE 1. Summary of studies included in semisystematic literature review (cont.)**

Research objective	Geographic area	Time frame	Method of delivery	Target population	Investigating agency	Number of respondents	Reference
Assessed current practices related to the use of biological soil amendments of animal origin and food safety risks in organic agriculture on produce commodities covered under the PSR.	National	2016	Mailed paper survey, online survey	Organic produce growers	University of California–Davis; U.S. Department of Agriculture, Agricultural Research Service	666 Growers	Pires et al., 2018 (25)
Evaluated consumers' food safety concerns and purchasing profiles regarding fresh produce and their preferences for produce grown by farms with GAPs.	New England	2001	Mailed paper survey	Consumer household	University of Rhode Island	742 Households	Pivarnik et al., 2005 (26)
Assessed the knowledge of and attitudes toward GAPs of home gardeners in New England.	New England	2004	Mailed paper survey	Gardeners	University of Rhode Island, University of Connecticut, Johnson and Wales University	762 Gardeners	Pivarnik et al., 2006 (27)
Enhanced understanding, knowledge of, and attitudes toward GAPs of home gardeners in New England.	New England	2005	Interviews, followed-up to 2004 paper survey of gardeners (27)	Gardeners	University of Rhode Island, University of Connecticut, University of Maine, University of Vermont, University of New Hampshire	94 Gardeners	Pivarnik et al., 2008 (28)
Measured knowledge of and attitudes toward on-farm food safety among small- and medium-sized farms in New England.	New England	2016	Mailed paper survey, online survey	Small- and medium-sized produce growers	University of Rhode Island, University of Connecticut, The Ohio State University, University of Vermont	301 Growers	Pivarnik et al., 2018 (29)
Assessed whether New York fruit and vegetable grower management of manure and compost, irrigation, and wash water quality conformed to federal guidelines.	New York	1998	Mailed paper survey	Produce growers	Cornell University, Cornell Cooperative Extension	213 Growers	Rangarajan et al., 2002 (30)

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**TABLE 1. Summary of studies included in semisystematic literature review (cont.)**

Research objective	Geographic area	Time frame	Method of delivery	Target population	Investigating agency	Number of respondents	Reference
Researched the economic impact of produce auctions on farms, the communities in which auctions are located, and the businesses of those who buy at the auction.	New York	2017	Interviews	Amish growers; produce auction sellers, buyers	Cornell University, Cornell Cooperative Extension	18 Growers, 18 buyers	Reid et al., 2018 (31)
Assessed the costs and returns of implementing food safety practices while maintaining or expanding market access.	New York	2014	Interviews	Produce growers	Cornell University, Cornell Cooperative Extension	80 Growers	Schmit et al., 2020 (32)
Assessed the needs of growers in the North Central region on how to prepare for PSR regulations.	Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin	Funding awarded in 2015	Online survey	Produce growers	Iowa State University	299 Growers	Strohbehn et al., 2018 (34)
Determined the food safety policies and practices of supermarkets that will impact local produce growers.	Pennsylvania	2009	Online survey	Supermarket chains	Pennsylvania State University	15 Supermarket chains	Tobin et al., 2011 (35)
Presented evidence regarding the ways in which changes in growers' GAPs knowledge, attitudes, and skills affect the GAPs tasks that they implemented.	Pennsylvania	2011	Paper survey at 8 on-farm food safety workshops	Produce growers	Pennsylvania State University	176 Growers	Tobin et al., 2013 (36)

practices (1, 3, 5, 7, 8, 15, 20, 36). A majority (66%) of growers surveyed by Bihn et al. (7) identified “financial resources” as the top limiting factor to implementation. In one study of Vermont growers, the initial GAPs certification cost for the average farm surveyed was estimated at \$46 per acre (5). The cost of produce safety compliance is variable but nonetheless problematic for many growers (1, 3, 8). Implementation costs were listed as a major barrier to compliance in studies across the United States (15, 20, 36). Produce buyers anticipated that they may lose some suppliers who cannot afford produce safety implementation (20).

Growers struggling to comply with produce safety standards also specifically identified infrastructure and equipment needs (15). In some cases, equipment could not be reliably sourced, or the technical skills and labor to provide proper produce safety measures were limited (15). Difficulties associated with locating, purchasing, and installing the needed infrastructure and equipment to improve produce safety held some growers back from compliance (15).

In a study of New York growers, when food safety practices were adopted to maintain or expand market access the economic value of the market was greater than the costs incurred to meet buyer standards (32). Although these economic benefits are higher for large farms that used a third-party audit, small- and medium-sized farms also had revenue increases that were greater than their food safety improvement costs (32).

#### **Key produce safety need identified: time**

Producer growers also expressed a need for more time to both improve and document their practices (5, 7, 16, 35). Becot et al. (5) estimated that the Vermont produce growers they surveyed would need an additional 7 h per week of labor to earn GAPs certification. Growers also needed time to work on a written food safety plan (16). Many reported that a barrier to proper produce safety practices was simply the amount of time it would take to get their operations into compliance, some citing an overall lack of available farm labor (7). In a study of Pennsylvania growers, Tobin et al. (35) reported that increasing technical assistance alone would not necessarily improve practices; survey respondents required more time for implementation.

#### **Key produce safety need identified: mindset**

Implementation of behavioral changes depends on motivation, perspective, and confidence, collectively referred to in this review as mindset. Some study authors recommended that educators and trainers begin by emphasizing past illnesses and outbreaks and highlight the importance of proper food safety risk management (23, 30). In contrast, Parker et al. (22), who interviewed growers in the midwestern United States, concluded that recently well-publicized outbreaks of foodborne illness may cause

producers to feel skeptical about the effectiveness of produce safety protocols.

Growers could be motivated to implement change by gaining a better understanding of the risks of microbial contamination and the pathways of contamination that apply to farms and production and processing areas (17, 28). Often, the motivation to make changes can come directly from the buyers of fresh produce (20). Tobin et al. (35) found that working with both growers and buyers (in this case, supermarket representatives) can help clarify the food safety needs of both groups. Consumer preferences and perceptions about the safety of purchased food may also provide motivation for growers (6, 26, 31). Prior to the PSR, decision making was guided by growers’ own choices and buyers’ preferences, and GAPs and other third-party certification programs were voluntary (4, 10, 20). Growers are now additionally motivated by the need to comply with the FSMA PSR (20). Researchers pointed out that on-the-ground employees, in addition to farm owners and managers, must have some motivation or incentive to comply with practices (10). Produce safety training and education for producers and buyers helps all parties gain an understanding of both the importance and complexities of the process (10).

Although growers must have the motivation to prioritize and take action to meet regulatory compliance, part of the educator’s duty is also to instill the confidence needed to take these actions, and produce safety training can increase growers’ confidence and intentions to make changes (21). Growers with a long history of compliance with food safety standards and culture had the most confidence in their ability to adapt to changing requirements (4). In contrast, Bihn et al. (7) found that some growers felt overconfident in their ability to assess and manage food safety risks, believing that they did not need training or behavior changes.

Outreach professionals should consider their methods of delivery (7, 27, 31). Bihn et al. (7) reported that among local food producers surveyed, preferred sources of food safety information were websites, written materials, and agricultural extension meetings or workshops. Growers’ preferred delivery methods for outreach and assistance differ widely and may have changed over the last two decades in response to changes in technology and shifting regulatory landscapes (27, 31).

#### **External factors influencing produce safety needs**

External nonproduce safety factors also influence the needs of growers, including region, farm size, farm type, and market (Figure 2). These externalities shape the way growers prioritize and approach produce safety in their operations.

#### **External factor influencing produce safety needs: region**

Production practices differ by region in the United States; therefore, the burden of regulatory compliance varies geographically (2, 25, 31). In a nationwide study, Adalja and

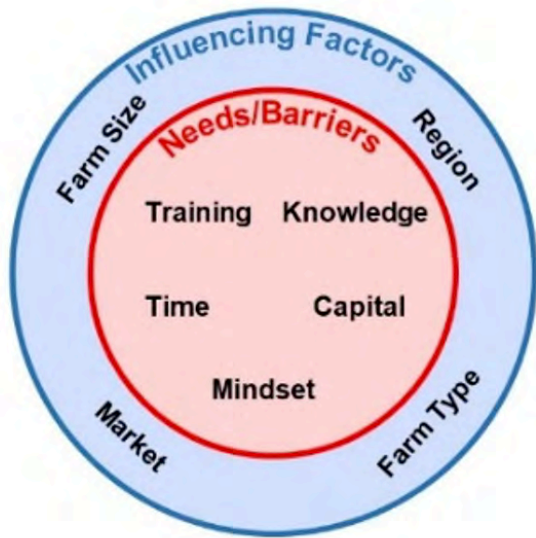


Figure 2. Identified produce safety needs and influencing factors for small- and medium-sized growers.

Lichtenberg (2) found that more work is required for growers outside the western United States to meet federal regulatory compliance. In a recent study of the use of biological soil amendments across the United States, and variety of practices were found (25). Cultural differences specific to geographic areas may impact the needs and preferences of groups of small- and medium-sized growers (31). In their work with Amish and Mennonite communities in New York, Reid et al. (31) found that outreach and education must be tailored to the specific cultural needs of their audience.

#### External factor influencing produce safety needs: farm size

Growers' produce safety needs differ by the size of the operation partly because the PSR affects farms of different scales differently and because practices differ depending on the operation's size and enterprise scale (3). Smaller farms often need to alter practices more than do larger farms to achieve regulatory compliance (3). For example, small- to medium-sized farms are heavily dependent on biological soil amendments of animal origin; thus, growers who use manure-based amendments need additional education on mitigation of produce contamination (25).

The financial burden of regulatory compliance for growers differs by farm size; the estimated cost per acre to meet regulatory compliance decreases as total acreage increases (1, 18). Smaller farms have an estimated compliance cost of  $\geq 1.0$  to 3.0% of their annual produce sales (1, 8). There also may be a difference in growers' knowledge of or access to information about the PSR by farm size, although in one survey no significant difference in GAPs knowledge was found by farm size (15). Pires et al. (25) examined food safety needs by the number of employees on the farm and

concluded that training on the farm may differ by farm size due to this factor. Parker et al. (24) found that although there may be scale-dependent differences in produce safety practices and needs, outreach professionals should not make assumptions based solely on the size of a produce operation.

In several studies, the authors noted that consumers often assume that "safer" produce comes from small farms (6, 26, 31). In the northeastern United States, many consumers perceive produce safety risks to be greater on large conventional farms and often choose to purchase produce from small organic farms instead (6, 26, 31). However, these consumer perceptions also may vary regionally; Parker et al. (22) addressed an underlying assumption in the midwestern United States that produce from small farms actually poses a greater food safety risk than does produce from large farms.

#### External factor influencing produce safety needs: farm type

The burden of compliance is not equal for all types of farms. Certified organic growers may already have adopted some food safety practices, therefore needing fewer changes for regulatory compliance (7, 30). The FDA may adopt National Organic Program standards for some recommended practices, such as the timing of manure applications (25). In contrast, some study results have indicated that the cost of compliance for "sustainable" growers may be greater than that for conventional growers (1, 2).

The burden of compliance for growers also differs by crop (8). A nationwide USDA study delineated the cost of compliance by main crop; for example, growers of romaine lettuce have less work to do to achieve regulatory compliance than do growers of snap beans (8).

Perhaps in support of the findings by Bihn et al. (7) related to grower overconfidence, Jackson et al. (15) found no significant difference in the GAPs-related needs of grower respondents by the number of years they had been farming.

#### External factor influencing produce safety needs: market

Current practices and needs may differ based on the primary market channel of the grower, although research on this topic has produced conflicting results (19, 32). Prior to the PSR, adoption of produce safety practices was voluntary (20). Some growers were motivated by buyers to attain third-party food safety certification to protect their economic interests (20, 29). Researchers at the University of Maryland and the University of Delaware surveyed growers in the mid-Atlantic United States and found that although a low percentage of the growers were GAPs certified, a significantly higher rate for adoption of food safety practices was found among growers who primarily sold their fresh produce through wholesale channels (19). Schmit et al. (32) found that in New York smaller farms sold primarily through direct-to-consumer markets and were less likely to have a third-party audit, whereas larger farms sold primarily through wholesale markets and were more likely to have a third-party

**TABLE 2. Most crucial and actionable needs identified through dot voting by meeting attendees**

Need	Dot voting tally (most crucial)	Dot voting tally (most actionable)
Capital	8	0
Knowledge	16	9
Mindset	4	20
Time	0	1
Training	18	13

audit. However, Lichtenberg and Tselepidakis Page (18) found little difference in produce safety practices of growers in the same region based on marketing channel. Bihn et al. (7) found that practices and needs may differ depending on the distribution distance, defining local growers as those who sell their produce within 275 miles (443 km) of their operation. However, Schmit et al. (32) asked growers for their top three reasons for implementing food safety practices and found that regardless of market the leading reason was a “personal commitment to produce a safer product.”

## CONCLUSIONS

There is an essential need to tailor outreach and education (both content and delivery) to the specific needs of produce growers and to consider the various ways in which those needs can differ among specific groups of growers and how those needs are influenced by external factors. Regardless of the delivery method, educational personnel must view the produce safety needs of their grower audience through a specific and contextual lens. Produce growers want information that comes from credible and experienced sources, and educators who can foster confidence by understanding the outside factors influencing the needs of their target audience and tailor programming to address those specific needs will have greater success in changing behaviors.

The key answer for educators looking for the best produce safety educational approach and content is that it depends on many factors. Rather than presenting a singular approach or set of resources, this review was designed to provide context and a framework for tailoring educational initiatives for specific audiences and individual growers. The process used for review of our findings helps to illustrate this benefit.

The findings of this semisystematic literature review were presented and discussed at the NECAFS Annual Conference and Meeting in Philadelphia, PA on 12 February 2020. At this meeting with >75 produce safety educators and regulators, the findings of this review were described, discussed, and verified. The most crucial and actionable needs were identified through participant voting. The semisystematic lit-

erature review provided a shared understanding and foundation for exploratory and normalizing action among the group.

The group spent >1 h engaged in a facilitated discussion establishing shared language by responding to the facilitator’s open-ended questions with personal knowledge and perspectives, and finally built consensus around the findings of this semisystematic literature review. By the conclusion of the discussion, the participants had gained an understanding of other perspectives and experiences and formed a more comprehensive understanding of the needs and influencing factors presented. The group unanimously verified the findings of the literature review while individually garnering a more contextualized understanding of the needs as informed through discussion with their regional partners. The participants were able to ground truth the findings, recognize their own experiences in the summary, and work on extending the findings to both collective and individual action.

The group then identified, through a voting process, the most crucial needs of growers based on the collective experience of the group of mostly educators and researchers (Table 2). The group then voted again and identified the needs of growers that were believed to be most actionable or most achievable, given current resources (Table 2).

The February 2020 exercise verified the findings of our literature review and confirmed that the results paralleled discussions among regional produce safety educational personnel who serve produce growers. The results of the voting highlight the areas seen as most crucial and actionable by these educational personnel and emphasize particularly salient needs of small- and medium-sized produce growers that need immediate attention. Educational personnel identified training, knowledge, and capital as the most pressing needs of the growers they serve. The group felt that the most actionable items to address with educational programming are mindset shifts, training, and knowledge.

Both the training and knowledge needs were identified as crucial and actionable. Therefore, educational personnel should prioritize development of educational materials in these areas and apply the information from this semi-systematic review when developing tools or trainings for small- and

medium-sized growers. Educational tools or trainings should include examples or case studies that differ in farm size, market, region, and farm type. Any output should be tailored to the area of need, consider the factors influencing growers, and take an approach that supports the ability of growers to individualize the information to their farms.

This review also highlights the longitudinal nature of produce safety education and implementation. Improvements in knowledge and practice take time. Much of this work is funded by grants with relatively short performance timelines. This review suggests that longer term projects may be needed to fully support adoption of food safety programs with direct technical assistance and to evaluate the impact of this produce safety education and technical support.

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## ACKNOWLEDGMENTS

The authors acknowledge the NECAFS needs assessment workgroup, who provided input during conference calls and a half-day in-person discussion to help guide and inform this semisystematic literature review process. The authors are grateful to Christie Silkotch (research librarian, Howe Library, University of Vermont) for informing our approach and providing guidance on database use. Funding for this work was provided by the Food Safety Outreach Program (USDA-NIFA-FSMA-2018-70020-28878). Without our sponsor, this work would not have been possible.

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