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Elizabeth G. Vandeputte

Lori F. Pivarnik

Joshua Scheinberg

Robson Machado

Catherine N. Cutter

*See next page for additional authors*

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**Authors**

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**An Assessment of Food Safety Handling Practices at  
Farmers' Markets in Rhode Island Using a Smartphone Application**

Elizabeth G. Vandeputte,<sup>a</sup> Lori F. Pivarnik,<sup>a\*</sup> Joshua Scheinberg,<sup>b</sup> Robson Machado,<sup>b</sup>  
Catherine N. Cutter,<sup>b</sup> and Ingrid E. Lofgren<sup>a</sup>

<sup>a</sup>Dept. of Nutrition and Food Sciences, University of Rhode Island, Ranger Hall, Kingston,  
Rhode Island, 02881, USA; <sup>b</sup>Dept. of Food Science, The Pennsylvania State University,  
University Park, Pennsylvania, 16802, USA

\* Corresponding author:

Phone: +1 401.874.2972; Fax: +1 401.874.2994

E-mail: [lpivarnik@uri.edu](mailto:lpivarnik@uri.edu)

## **ABSTRACT**

From 2001 to 2010, foodborne illness outbreaks increased in the United States and 17% of the outbreaks were from produce. Higher risk, whole produce that are sold at farmers' markets present unique challenges to food safety practices in regards to temperature controls, potable water, and exposure to contaminants. The purpose of this study was to use direct observations to identify unsafe food handling practices among vendors selling higher risk produce at Rhode Island farmers' markets. This study used a Smartphone application as a tool for data acquisition, developed to perform concealed direct observations of actual vendors' practices at farmers' markets. Observations were made at fourteen (7 state and 7 private) farmers' markets to collect food handling practices of 26 vendors selling high-risk produce. The mean observation time per vendor was  $18.3 \pm 5.8$  minutes. Vendors had unsafe food handling practices that included eating, talking on the phone and touching money and then touching produce. Use of a Smartphone application was an effective data collection tool in assisting the observer in the recording of farmers' market vendor practices, without detection. The results of this study will be used as guidance for education programs targeting farmers' market managers and vendors that promote best practices in regards to whole produce.

## INTRODUCTION

In 2011, it was reported that approximately 48 million Americans contract foodborne illnesses annually, which is equivalent to one in every six Americans (27). Thirty-one known foodborne pathogens caused 44% of the identified foodborne illness cases that led to hospitalizations and 44% that led to death (27). A report from the Centers for Disease Control and Prevention stated that among all reported outbreaks occurring from 1998-2008, 46% of illnesses were attributed to commercially sold produce, with leafy-green vegetables having the highest association with outbreaks when compared to other produce commodities (18). Furthermore, from 1996 to 2010, 131 documented, produce-related reported outbreaks occurred, which resulted in 14,132 illnesses, 1,360 hospitalizations, and 27 deaths (35). The Food and Drug Administration (FDA) delineates higher risk produce as produce that presents a risk of serious adverse health consequences or death; examples are berries, leafy green vegetables, tomatoes, cucumbers, melons, and fresh herbs (35).

In an effort to provide farmers with methods to reduce the microbial contamination of fresh and minimally processed fruits and vegetables, the FDA and the United States Department of Agriculture (USDA) developed the Good Agricultural Practices (GAP) program, following the release of the 1998 FDA “Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables” (34). Good Agricultural Practices are a set of voluntary guidelines for commercial farmers that address numerous factors related to produce production, such as water safety, application of compost/manure, field/worker hygiene/sanitation, handling produce after harvesting, and transportation from the farm (21). In 2010, the US Congress passed the Food Safety Modernization Act which mandates that the FDA promulgate rules that address food safety during harvesting, processing, transporting, and also includes provisions for food defense

(35). Among these proposed rules, the Produce Safety Rule, “Standards for the Growing, Harvesting, Packing and Holding of Produce for Human Consumption,” (21 CFR Part 112) targets the reduction of pathogen contamination in produce by commercial growers (35). This proposed rule includes evidence-based standards that identify specific higher risk produce that are commonly contaminated by pathogens and lead to foodborne illness outbreaks (35).

From 1970 to 2005, the consumption of produce in the US increased approximately 20% (36), and is expected to increase as the population rises to approximately 331 million by 2020 (5, 30). This increase in produce consumption in the US may reflect an increase of the popularity of farmers’ markets for purchasing fruits and vegetables (1, 35). However, the Produce Safety Rule does not target direct marketing, e.g. farmers’ markets for produce handling. Therefore, produce safety practices of farmers’ market vendors need to be assessed to help maintain the safety of produce from farm to table.

Since 1994, the number of farmers’ markets in the US has increased significantly from 1,755 to 8,268 markets in 2014 (1, 22). Farmers’ markets have unique food safety issues, separate from those faced in a traditional supermarket. Many of these risks are due to environmental factors, since many farmers’ markets are located outside or in temporary building structures. At these venues, food products can be exposed to environmental contaminants and a public infrastructure that may be lacking (e.g. electricity, running water, and soap) (3, 6, 16, 33). Furthermore, the food safety knowledge and skills of vendors and market organizers may be variable. Due to their increased popularity, farmers’ market vendor's food safety practices have become increasingly important; however there is limited research that has investigated vendor food handling and food safety practices at the market.

Concealed direct observations can be used to assess food handler's food safety practices doing everyday tasks without the observed party being aware of the observation (25, 37, 38). Using concealed direct observations, the observer can pose as a consumer while collecting observations of retail workers. Concealed direct observations provide an accurate accounting of behavior and allow for the observer to capture behaviors directly rather than relying on biased self-reporting in which food handlers can overestimate the frequency in which food safety practices are carried out (3, 7, 8, 15). Another advantage to using concealed observations versus direct observations is the avoidance of the Hawthorne Effect. The Hawthorne Effect—bias and artificial behavior change due to awareness of being observed—can greatly impact the results, making the direct observations less valid (3, 8, 12, 15). Direct observations have been successfully used to assess the performance of workers in a variety of businesses (3, 10, 14); however there is limited research on using this method to assess food safety handling practices of farmers' market vendors. Mystery shopping, or concealed direct observations, is a way for an observer to reduce the bias found with a traditional interview, survey research and/or self-report (25, 38). Mystery shopping has typically involved the use of concealed direct observations with paper-based inspection/checklists which are completed by memorization of the observed behaviors and recording data after the event. This method can result in the loss and reduced quality of data collection due to poor recall of the observation (7, 8, 14, 37). While concealed direct observation enhances the effectiveness and reliability of observational collection of data, this observational method could be improved if documentation could be “real time” data recording. This would allow for better evaluation of food safety handling practices of produce vendors at farmers' markets.

The purpose of this study focused on the assessment of vendor food handling practices of higher risk produce sold at farmers' markets in Rhode Island (RI) using mystery shopping protocol. The goal of the study was to record vendor handling practices in "real time", using the customized Smartphone application (SA), "Food Safe Surveys" and to determine the prevalence of safe and unsafe food handling practices of higher risk produce sold at farmers' markets in RI.



## **MATERIALS AND METHODS**

### **Study design**

This was a descriptive study using concealed direct observations (3, 8, 15, 25, 38), of vendors at RI farmers' markets using an Android mobile SA for primary data collection. The SA was used as a data collection instrument instead of using current mystery shopping protocol requiring memory and manual record keeping (10, 14). This study was approved by the University of Rhode Island (URI) Institutional Review Board. The goal of this study was to assess food handling practices via concealed direct observation using a SA.

### **Selection of farmers' markets and vendors**

The sample population consisted of RI farmers' market vendors who appeared to be over the age of eighteen and were selling higher risk produce such as berries, leafy green vegetables, tomatoes, cucumbers, melons and fresh herbs (35).

During the summer of 2013, there were 54 RI farmers' markets: 9 were state-run and 45 were privately run. Several demographic variables were used in the selection of farmers' markets including: state vs. privately operated and urban versus rural sites. Fourteen outdoor farmers' markets were chosen (7 state and 7 private), and 26 vendors were selected for the observational study. This sample size was chosen per on a previous study protocol that observed 18 farmers' market employees (3). The farmers' markets were identified as rural or urban sites using the RI rural and urban Census Places definitions (31). These definitions delineate several levels of rural and urban populations. A farmers' market was considered rural if the location consisted of a population  $\leq 50,000$  people and urban if the population was  $> 50,000$  people (31).

## **Development of application as observational tool for mystery shopping**

Using modified protocol as delineated by Behnke et al. (3), a mobile SA was developed as a data collection tool. Behnke et al. (3), used a Smartphone and SA to capture direct observations of food handling transactions and food safety behaviors of farmers' market employees. While this study by Behnke et al. (3) targeted farmers' market vendors, the results did not specifically focus on produce vendor handling practices; cleanliness of the farmers' market and vendor stand, location of the market, protection of the vendor stand, and whether or not there was any processing of the produce at the market.

The mobile SA, "Food Safe Surveys" was developed at AHG, Inc (300 D. Pugh. St., State College, PA) through collaboration with the Department of Food Science, at The Pennsylvania State University and the Nutrition and Food Sciences Department, URI. The mobile SA was designed for use on an Android platform (9). Specifically this SA, consisted of a mobile device application that was networked to a web-based interface (9). This system allowed users to design custom questionnaires, surveys, or checklists via a web based system. The surveys were downloaded to the Food Safe Surveys program on the Smartphone to be used in applications for an easy-to-use interface. The surveys developed and the data collected were kept secured and password-protected, both on the web and the mobile device interfaces (9).

The SA was used for real-time data collection that enabled the observer to record actual behavior or handling practices more efficiently. The SA was developed to allow data entry in specific fields on a Smartphone and all collected data could be downloaded onto a computer or SD card and data imported into Excel. Excel data would be imported to Statistical Package for Social Sciences (SPSS) for analysis. However, initial problems with the export feature of the SA

required that the data, for this study, to be manually entered into Excel and then imported into SPSS during this study. Answers to all questions were limited to password enabled researchers.

### **Smartphone application questions**

An expert advisory committee, with members from the RI Department of Health (RIDOH) and RI Department of Environmental Management (RIDEM) helped define areas to be addressed during this study by answering questions pertaining to licensure and costs for farmers' markets, number of farmers' market certifications, products that can be sold at farmers' markets, degree of regulatory oversight and key food handling practices and behaviors that should be observed. Members of the expert advisory group answered questions designed to clarify food safety recommendations within the RIDOH 2007 Food Code and how to apply the recommendations to RI farmers' market produce vendors (24). Interview questions were adapted from a previously designed questionnaire developed and reviewed for regarding critical and emerging food safety issues pertaining to state regulators' oversight of farmers' markets (20).

The advisory committee members included: the Compliance Evaluation/Standardization Officer at the Division of Food Protection at the RIDOH and Chief of the Office of Food Protection at the RIDOH and Chief division of agriculture at the RIDEM and Deputy Chief Division of Agriculture RIDEM. Each member of the advisory group was interviewed separately. Using the answers from the interviews, areas of shared interest and concern in relation to food safety practices of higher risk produce vendors at farmers' markets were identified. Questions for the mobile SA reflected both results of the advisory group interviews and general accepted food safety handling practices.

### **Smartphone application "Food Safe Surveys" questions**

Using the web-based Food Safe Surveys interface, fifty-four survey questions were uploaded onto the Food Safe Surveys SA. The 54 questions represented the 54 items which the observer would document, in order, during a concealed direct observation session. Question formats consisted of yes/no, multiple choice, two-point scales, and free form text entry questions. The two-point scale consisted of 1 = unclean and, 2 = clean.

The two-point scale for unclean and clean was used to define the overall cleanliness of the farmers' market, the vendor stand, and the individual vendor. The farmers' market was considered unclean if there were environmental contaminants visible, such as animal droppings or pet-animals present at the market, while clean was classified as a farmers' market located on an area of managed grass or a parking lot with no animal droppings and no dirty tents or tables. The vendor stand was considered unclean if dirty tables, containers, or visible soiled spots on tablecloths or tents were present, and classified as clean if the vending table was clear of dirt, visible soiled areas, and presented high-risk produce hygienically in containers absent of dirty water. Lastly, the farmers' market vendor was classified as unclean if the vendor had dirty nails, clothing which were soiled, and were classified as clean if the vendor's clothes were clean with no visible dirt or soiled areas.

The 54 questions were organized into three categories. The first category, farmers' market demographics (7 questions), was based on data produce by the RIDEM "Directory of Rhode Island Farmers' Markets" and was answered prior to arriving at the farmers' market (23). The name of the farmers' market was entered and each vendor was identified using a random three-digit code. Once at the farmers' market, the second category reflected the overall farmers' market environment, which consisted of 10 questions. The third category, vendor handling characteristics and higher risk produce consisted of 37 questions and were answered after

choosing which produce vendors to observe at the market. Vendors were chosen to reflect a variety of higher risk produce. Evidence of GAP certification was if there was a sign available to see at the vendor stand. Complete observational assessments were made for 1 to 2 vendors per market depending on 1) size of market, and 2) produce sold-higher risk only. For example, a smaller market may have had only one vendor selling higher risk produce. Recorded observations were edited, if necessary, to clarify wording but not change overall content. At two farmers' markets, only one vendor could be observed due to the fact that there was only one higher risk produce vendor present.

### **Farmers' market vendor observation**

Observations of farmers' market vendors were performed between July and August 2013 at 14 RI farmers' markets. One to two vendors were observed at each farmers' market for a total of 26 vendors. Only vendors selling higher risk produce were selected and vendors were chosen to reflect a variety of commodities. Each vendor was observed one time for 10-30 minutes depending on the size of the market. Vendors at smaller markets were observed for the shorter time period to avoid being recognized. Smaller markets were characterized by the limited number of produce vendors handling higher risk commodities. Observations were conducted during busy times at the farmers' markets because handling of produce was highest at this time and it allowed the observer to be less conspicuous while conducting assessments. Randomly generated code numbers were used for identification for data entry to ensure there was no connection between vendor and number. Therefore, vendor anonymity was maintained once data was recorded. Observations were used to evaluate the vendor's food safety practices in relation to higher risk whole fresh produce (such as berries, leafy green vegetables, tomatoes, cucumbers,

melons and fresh herbs) (35). Figure 1 presents a screenshot of the SA “Food Safe Surveys” and example questions used in the observational assessment.

### **Data analysis**

Data analysis was performed using SPSS version 22.0 for Windows. Descriptive statistics were assessed. Categorical variables were presented by (frequencies, percentages) and continuous variables were presented as means  $\pm$  standard deviations. Chi-square tests or Fisher’s Exact test (when the cells had an expected count less than five) were performed to compare 1.) the type of farmers’ market (private and state), 2.) the area (rural and urban), 3.) the presence of hand washing facilities and bathrooms available, and 4.) the overall cleanliness of the market. The *P*-value for all statistical tests was set at  $P < 0.05$ .

## **RESULTS**

## Demographics

Twenty-six produce vendors at 14 RI farmers' markets were directly observed using the SA "Food Safe Surveys" during the months of July through August 2013. One to two vendors were observed at each farmers' market. Only one vendor was observed at two out of the 14 farmers' markets, since it was the only higher risk produce vendor at the market; two higher risk produce vendors were observed at the other 12 farmers' markets.

Table 1 shows the demographic characteristics of the farmers' markets observed in RI (7 state and 7 private) which were predominately located in rural areas (71%). Vendors were observed an average of  $18.3 \pm 5.8$  minutes per vendor. Six farmers' markets had  $<4$  higher risk produce vendors present and 8 farmers' markets had  $\geq 4$  higher risk produce vendors present.

Among observed farmers' markets, 10 (71%) were categorized as unclean, reflecting the common occurrence of environmental contaminants such as geese droppings and the presence of pet-animals at the market. Only 4 (29%) of observed farmers' markets were categorized as clean, reflecting farmers' markets operating on clean cut grass or a clean parking lot with no animal droppings or pet-animals. Out of the 14 farmers' markets observed, only one market provided a hand washing facility available to customers with both water and soap, while three farmers' markets provided bathrooms available for customers. Among those markets with bathrooms, two of the bathrooms provided both water and soap, and one bathroom only provided hand sanitizer.

Figure 2 shows the frequency at which high-risk produce was present and handled at observed farmers' markets. The top most frequently present and observed higher risk fruits were blueberries (8 vendors, 31%), peaches (7 vendors, 27%), and red raspberries (5 vendors, 19%). The top most frequently present and observed higher risk vegetables were tomatoes (17 vendors, 65%), zucchini (16 vendors, 62%), and peppers (15 vendors, 58%).

Key farmers' market demographic variables, type of farmers' market (private or state), and area of farmers' markets (rural or urban), were compared to overall cleanliness of market, hand washing facilities available and bathrooms available, no significant differences were observed. However, more farmers' markets might need to be observed to evaluate significance due to the lower than expected counts required for more reliable statistical assessment.

### **Higher risk produce**

Twenty-four (92%) of the 26 vendors had their produce protected, as recommended by RIDEM and RIDOH (Table 2). Higher risk produce was considered protected if the vendor stand had a tent to cover the produce, if the produce was on top of a table in plastic or wooden container, and/or if it was in coolers. Of the 24 vendors that protected their produce, all 24 (100%) had a tent with their produce on a table in plastic or wooden containers. None of the vendors were selling their produce precut and were not processing onsite.

While the majority of vendors stored the produce off the ground at the farmers' markets, 9 vendors (35%) stored the produce directly on the ground (Table 2). Produce was considered off the ground if it was on the table or on a pallet. Crated produce directly on the ground was not considered acceptable per RIDOH guidance. The most frequently observed types of higher risk produce stored on the ground were cucumbers, onions, and tomatoes. Fifteen vendors (58%) had produce which appeared discolored, and/or having brown marks or indents and were classified as lightly bruised. The top five most frequently observed types of bruised produce were tomatoes, radishes, peaches, blueberries, and onions.

### **Vendor handling practices**



Out of the 26 vendors observed, 21 (81%) were categorized as unclean and 5 (19%) were clean (Table 2). Vendors were classified as unclean if the vendor had dirty nails and/or dirt on their clothes. Vendors were classified as clean if they had clean clothes with no visible dirt on them. Nineteen (73%) of the vendor food stands were considered unclean because the produce tables were dirty, water in containers was dirty and/or the tent had any visible dirt or holes. During each vendor observation a range of 1 to 15 money transactions were observed. During these observations, no vendors wore gloves. In these instances, vendors were observed touching money and then handling produce. None of the vendors observed provided a hand washing facility at their stand. In addition, none of the vendors were observed washing their hands at any time during the observations.

Table 3 lists other unsafe food safety vendor behaviors, which also were recorded during the observations. Unsafe behaviors were classified as those actions performed by the vendor which could compromise food safety. These observed behaviors included: leaving the vendor stand unattended, touching their body or money, eating and/or drinking, and talking on the phone, with no hand washing performed after those behaviors and before handling food items. While the FDA Food Code (2-40.11) would allow drinking by employees from a closed beverage container if handled to prevent contamination of employee's hands, the container and exposed food (24), 5 of 8 vendors were also eating food – a behavior that should be done in a designated area to avoid microbial contamination of food. It appeared that drinks had covers, but this was not recorded. The most frequently observed unsafe behavior was the handling of money and then produce (81%), with no hand washing performed. Eight (32%) out of 26 vendors also ate or drank and then touched produce.

## **DISCUSSION**

This study showed that RI farmers' market vendors had many correct behaviors that would address key food safety concerns. However, this study, did find that farmers' market vendors do not always utilize best practices for higher risk produce, which could increase the risk of foodborne illnesses. This study also showed that vendors rarely distributed food safety information pertaining to the produce to their customers.

Vendors are usually engaged in multiple tasks which can increase the risk of contamination of produce (3, 16). In this study, vendors were observed touching money (81%) and eating and/or drinking (32%) without washing their hands before touching produce, which increases risk of pathogens being transferred to produce. Money can harbor multiple contaminants such as fecal coliforms and *Staphylococcus aureus*, that can survive for extended time periods, and can be transferred to an individual's hands (2, 16). Other unsafe vendor practices observed were vendors touching their bodies (8%) immediately before touching produce. Personal and hand hygiene are very important for farmers and farmers' market vendors, especially after working in fields and applying manure based fertilizer (13). Farmers and farmers' market vendors need to use safe hygienic practices to prevent pathogens such as *E. coli* O157:H7 and *Salmonella* from contaminating the produce (13, 19). For example, Harrison et al., (13) noted that a considerable number of farmers surveyed were harvesting without easy access to handwashing facilities, and a majority did not regularly clean transport containers from the farms to the markets. The study showed that the lack of farmer hygiene practices, coupled to the fact that over 40% of markets reported no food safety standards in place, could lead to an increased food safety risk. Furthermore, similar studies have observed that vendors conducting multiple tasks at farmers' markets tend to touch money and clothes more often (3, 16), which could lead to an increased possibility of contamination from vendor to the produce.

Only three of the 14 farmers' markets observed in this study provided a bathroom available for both vendors and customers, and only 2 had water and soap available. One bathroom contained hand sanitizer, which is not recommended as an alternative to handwashing with soap and water. The lack of handwashing facilities with soap and water could result in an increased risk of microbial contamination. A study assessing food safety practices at farmers' markets by Behnke et al. (3), showed that out of eighteen vendors only nine had access to hand washing facilities, which again shows the lack of infrastructure at farmers' markets, making it hard for vendors to follow health or market guidelines for washing hands. Hygienic issues were also documented in an observational study of Canadian vendors at farmers' markets by McIntyre et al. (16). This study showed limited hand washing by vendors and lack of facilities at the markets. Less than half of the markets observed had facilities and even less had warm running water (16). This highlights the importance of vendors and market managers working together to get infrastructure in place at farmers' markets to help decrease the risk of foodborne illnesses (6).

The results of this study illustrated that the majority of farmers' market vendors placed produce under tents, on a table in plastic or wooden containers. Use of coolers was also observed, but the presence of ice or thermometers could not be determined. Tents can protect produce from environmental contaminants. Covering will also help protect exposure of sensitive produce from the hot sun which can indirectly lead to pathogenic microbial infiltration and proliferation when quality is compromised (29). A study conducted by Harrison et al. (13), explained how the cooling or shading of produce from sunlight during postharvest handling could be important in controlling food safety risks of produce. During the direct consumer marketing of produce at farmers' markets, items sit in the hot sun or hot conditions for extended

timeframes; thus resulting in changes to produce that could lead to risk of contamination and bacterial growth.

Additionally, no vendors were observed cutting the produce at their stand and no vendors were seen selling pre-sliced, cut, or chopped produce. These practices would be considered a food safety risk by the RIDOH if proper handling and/or cooling were not followed. However, produce handling practices were observed which could increase the risk of contamination. Some higher risk produce (35%), such as cucumbers, onions, and tomatoes, were stored directly on the ground or in boxes that were directly on the ground, as delineated previously. Exposure to the ground could greatly increase the risk of exposure to contaminants present in those environments (26). A majority of the observed produce (58%) also was found to be lightly bruised. The bruising of vegetables can increase their susceptibility to being infected by pathogens such as *Salmonella*, *E. coli*, and *Listeria monocytogenes* (4).

This study demonstrated the successful use of the SA, “Food Safe Surveys”, and its ability to be used for concealed direct observations of vendors selling produce at farmers’ markets. Previous research has demonstrated that if observed individuals are aware they are being observed, they tend to change their behaviors to match what they think the observer would consider appropriate (3, 7, 8). A study conducted by Srigley et al. (28), concluded that hand hygiene compliance was higher when healthcare workers knew they were being observed, compared to when workers had no knowledge of being observed. The Hawthorne Effect appeared to be minimized during this study for market vendor behaviors, due to the use of the SA and subsequent observation of key food safety handling practices by vendors that would result in increase produce safety risks.

During the observations of farmers' market vendors, only one vendor was observed providing verbal food safety information to their customers. Since vendors have the opportunity to communicate face-to-face with their consumers, they have a unique opportunity to convey important food safety information, such as produce washing recommendations (11, 17, 32, 36). A study conducted by Harrison et al. (13), showed that over 40% of farmers and 60% of market managers expressed an interest in receiving food safety training materials for their workers on farms and for vendors and market workers at farmers' markets.

A strength of this study was the use of a Smartphone to record concealed direct observations on farmers' market vendor food handling practices. This Food Safe Surveys SA was shown to be successfully used in an applied research study. Previous studies utilizing Smartphones for data recording described difficulties in areas with no internet or data connection (3). Those issues were not encountered due to the ability of Food Safe Surveys to operate without an internet connection. Additionally, it is assumed that the SA greatly decreased the Hawthorne Effect, due to the fact that the observer looked as though they were texting on a Smartphone, a very common occurrence. This study also had an increased sample size and specifically looked at handling practices of produce when compared to the study by Behnke et al. (3).

## **CONCLUSION**

The results of this study revealed that while some vendors at RI farmers' markets were observed to follow good food handling practices, many vendors were observed performing various unsafe handling practices of produce. The SA, Food Safe Surveys, also was found to be an effective data collection tool in assisting the observer in the recording of farmers' market vendor practices, without detection. This study also demonstrated the need for farmers' market vendor food safety training and educational materials on best handling practices for produce. The information on the handling practices of higher risk produce collected from this study will be incorporated into educational materials that are currently being developed for farmers' market outreach.

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## REFERENCES

1. Agricultural Marketing Service (AMS). 2014. National count of farmers markets directory listings. Available at:  
<http://www.ams.usda.gov/AMSV1.0/ams.fetchTemplateData.do?template=TemplateS&leftNav=WholesaleandFarmersMarkets&page=WFMFarmersMarketGrowth&description=Farmers+Market+Growth>. Accessed 12 January 2015.
2. Barro, N., A. R. Bello, A. Savadogo, C. A. T. Ouattara, A. J. Iiboudo, and A. S. Traore. 2006. Hygienic status assessment of dish washing waters, utensils, hands and pieces of money from street food processing sites in Ouagadougou (Burkina Faso). *Afr. J. Biotechnol.* 5:1107-1112.
3. Behnke, C., S. Seo, and K. Miller. 2012. Assessing food safety practices in farmers' markets. *Food Prot. Trends.* 32:232-239.
4. Beuchat, L. R. 2002. Ecological factors influencing survival and growth of human pathogens on raw fruits and vegetables. *Microbes Infect.* 4:413-423.
5. Blisard, N., and B. H. Lin, J. 2002. America's changing appetite: Food consumption and spending to 2020. *Food Rev., Washington, D.C.* 25:2-9.
6. Brannon, L. A., V.K. York, K. R. Roberts, C. W. Shanklin, and A. D. Howells. 2009. Appreciation of food safety practices based on level of experience. *J. Foodservice Bus. Res.* 12:134-154.
7. Clayton, D. A., C. J. Griffith, P. Price, and A. C. Peters. 2002. Food handlers' beliefs and self-reported practices. *Int. J. Environ. Health Res.* 12:25-39.
8. Clayton, D. A., and C. J. Griffith. 2004. Observation of food safety practices in catering using notational analysis. *Br. Food J.* 106:211-227.



9. Cutter, C. 2012. Personal communication. Professor and Food Safety Extension Specialist. Pennsylvania State University.
10. Finn, A., and U. Kayande. 1999. Unmasking a phantom: a psychometric assessment of mystery shopping. *J. Retailing*. 75:195-217.
11. Fishburn, J. D., Y. Tang, and J. F. Frank. 2012. Efficacy of various consumer-friendly produce washing technologies in reducing pathogens on fresh produce. *Food Prot. Trends*. 32:456-466.
12. Green, L. R., C.A. Selman, V. Radke, D. Ripley, J. C. Mack, D. W. Reimann, T. Stigger, M. Motsinger, and L. Bushnell. 2006. Food worker hand washing practices: An observation study. *J. Food Prot.* 69:2417-2423.
13. Harrison, J. A., J. W. Gaskin, M. A. Harrison, J. L. Cannon, R. R. Boyer, and G. W. Zehnder. 2013. Survey of food safety practices on small to medium-sized farms and in farmers markets. *J. Food Prot.* 76:1989-1993.
14. Hesselink, M., J. V. Iwaarden, and T. V. D. Wiele. 2005. Mystery shopping: A tool to develop insight into customer service provision. *Total Qual. Manag. Bus.* 16:529-541.
15. Lubran, M. B., R. Pouillot, S. Bohm, E. M. Calvey, J. Meng, and S. Dennis. 2010. Observational study of food safety practices in retail deli departments. *J. Food Prot.* 73:1849-1857.
16. McIntyre, L., Karden, L., Shyng, S., and Allen, K. 2014. Survey of observed vendor food-handling practices at farmers' markets in British Columbia, Canada. *Food Prot. Trends*. 34:397-408.

17. New York State Department of Health. Drinking water. Available at: <http://www.health.ny.gov/environmental/water/drinking/regulations/>. Accessed 18 February 2013.
18. Painter, J. A., R. M. Hoekstra, T. Ayers, R. V. Tauxe, C. R. Braden, F. J. Angulo, and P. M. Griffin. 2013. Attribution of foodborne illnesses, hospitalizations, and deaths to food commodities by using outbreak data, United States, 1998–2008. *Emerg. Infect. Dis.* 19:407-415.
19. Park, C. E., and G. W. Sanders. 1992. Occurrence of thermotolerant campylobacters in fresh vegetables sold at farmers' outdoor markets and supermarkets. *Can. J. Microbiol.* 38:313-316.
20. Pivarnik, L. 2012. Personal communication. Coordinator, Food Safety Outreach/Research Nutrition and Food Sciences Department. University of Rhode Island.
21. Pivarnik, L., N. L. Richard, M. Patnoad, R. Gable, D. Handley, D. W. Hirsch, D. Steen, and C. Violette. 2008. TI: On-site interview of New England gardeners to assess food safety knowledge and practices related to growing and handling of home grown fresh fruits and vegetables. *Food Prot. Trends.* 28:115-124.
22. Ragland E., and D. Tropp. 2009. USDA national farmers market manager survey 2006. Available at: <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5077203>. Accessed 11 February 2013.
23. Rhode Island Department of Environmental Management. 2009. Directory of Rhode Island farmers' markets. Available at: <http://www.dem.ri.gov/programs/bnatres/agricult/pdf/rimarkets.pdf>. Accessed 16 March 2013.
24. Rhode Island Department of Health. 2007. Food code: State of Rhode Island and Providence Plantations Department of Health 1994. Available at:

<http://sos.ri.gov/documents/archives/regdocs/released/pdf/DOH/4885.pdf>. Accessed 3 February 2013.

25. Richard A. E., J. L. Brown, R. B. Radhakrishna, E. P. Yoder, S. Nieto-Montenegro, C. N. Cutter. 2013. Development and implementation of a counter-top training program to increase retention of food safety knowledge, alter behavior, improve attitude and increase skills of spanish-speaking retail employees. *Food Prot. Trends*. 33:10-19.

26. Rushing, J. W. 2010. Improving the safety and quality of fresh fruits and vegetables: a training manual for trainers. Available at:

[http://jifsan.umd.edu/docs/gaps/en/GAPs\\_Manual\\_\(Compiled\).pdf](http://jifsan.umd.edu/docs/gaps/en/GAPs_Manual_(Compiled).pdf). Accessed 18 March 2014.

27. Scallan, E., R. M. Hoekstra, F. J. Angulo, R. V. Tauxe, M. A. Widdowson, S. L. Roy, J. L. Jones, and P. M. Griffin. 2011. Foodborne illness acquired in the United States—major pathogens. *Emerg. Infect. Dis.* 17:7-15.

28. Srigley, J. A., C. D. Furness, G. R. Baker, and M. Gardam. 2014. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. *BMJ Qual. Saf.* 23: 974-980.29. Suslow, T. V., M. P. Oria, L.

R. Beuchat, E. H. Garrett, M. E. Parish, L. J. Harris, J. N. Farber, and F. F. Busta. 2003.

Production practices as risk factors in microbial food safety of fresh and fresh-cut produce.

*Compr. Rev. Food Sci. Food Saf.* 2:38-77.

30. U.S. Department of Agriculture. 2007. Food consumption and nutrient intakes. Available at: <http://www.ers.usda.gov/data-products/food-consumption-and-nutrient-intakes.aspx#26667>.

Accessed 11 February 2013.

31. U.S. Department of Agriculture. 2007. Rhode Island. Available at:  
[http://www.ers.usda.gov/datafiles/Rural\\_Definitions/StateLevel\\_Maps/RI.pdf](http://www.ers.usda.gov/datafiles/Rural_Definitions/StateLevel_Maps/RI.pdf). Accessed 2 October 2014.
32. U.S. Department of Agriculture and U.S. Department of Health and Human Services. 2010. Dietary guidelines for americans, 2010. Available at:  
[http://www.cnpp.usda.gov/sites/default/files/dietary\\_guidelines\\_for\\_americans/PolicyDoc.pdf](http://www.cnpp.usda.gov/sites/default/files/dietary_guidelines_for_americans/PolicyDoc.pdf). Accessed 24 January 2013.
33. U.S. Food and Drug Administration. Analysis and evaluation of preventive control measures for the control and reduction/elimination of microbial hazards on fresh and fresh-cut produce. Available at:  
[www.fda.gov/food/foodscienceResearch/safepracticesforfoodprocesses/ucm091265.htm](http://www.fda.gov/food/foodscienceResearch/safepracticesforfoodprocesses/ucm091265.htm). Accessed 24 January 2013.
34. U.S. Food and Drug Administration. 1998. Guidance for industry: Guide to minimize microbial food safety hazards for fresh fruits and vegetables. Available at:  
<http://www.fda.gov/downloads/Food/GuidanceRegulation/UCM169112.pdf>. Accessed April 4 2015.
35. U.S. Food and Drug Administration. 2013. Standards for the growing, harvesting, packing and holding of produce for human consumption. Available at:  
<http://www.gpo.gov/fdsys/pkg/FR-2013-01-16/pdf/2013-00123.pdf>. Accessed 25 March 2013.
36. Verrill, L., A. M. Lando, and K. M. O'Connell. 2012. Consumer vegetable and fruit washing practices in the United States, 2006 and 2010. *Food Prot. Trends*. 32:164-172.
37. Wilson, A. M. 1998. The role of mystery shopping in the measurement of service performance. *Manag. Serv. Qual.* 8:414-420.

38. Wilson, A. M. 2001. Mystery shopping: Using deception to measure service performance. *Psychol. Marketing*. 18:721-734.

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**TABLES**

**Table 1. Demographic characteristics of farmers' markets observed in Rhode Island (N=14)**

	<b>Frequency</b>	<b>Percent</b>
<b>Type of farmers' market</b>		
State	7	50
Private	7	50
<b>Location of the farmers' market</b>		
Rural	10	71
Urban	4	29
<b>Overall cleanliness of the farmers' market</b>		
Unclean	10	71
Clean	4	29
<b>Hand washing facilities available</b>		
No	13	93
Yes	1	7
<b>If yes to previous question, (N=1)</b>		
<b>Was water available</b>		
No	0	0
Yes	1	100
<b>Was soap available</b>		
No	0	0
Yes	1	100
<b>Was hand sanitizer available</b>		
No	1	100
Yes	0	0
<b>Bathrooms available</b>		
No	11	79
Yes	3	21
<b>If yes to previous question, (N=3)</b>		
<b>Was water available</b>		
No	1	33
Yes	2	67
<b>Was soap available</b>		
No	1	33
Yes	2	67
<b>Was hand sanitizer available</b>		
No	2	67
Yes	1	33

**Table 2. Produce handling characteristics of observed farmers' market vendors in Rhode Island (N=26)**

	<b>Frequency</b>	<b>Percent</b>
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<b>Evidence of GAP certification</b>		
No	26	100
Yes	0	0
<b>Language other than English spoken</b>		
No	24	92
Yes	2	8
<b>Did the vendor provide food safety information</b>		
No	25	96
Yes	1	4
<b>Overall cleanliness of the food stand</b>		
Unclean	19	73
Clean	7	27
<b>Overall cleanliness of the vendor</b>		
Unclean	21	81
Clean	5	19
<b>Were gloves worn to handle high-risk produce</b>		
No	26	100
Yes	0	0
<b>Were hand washing facilities available at the vendor stand</b>		
No	26	100
Yes	0	0
<b>Did vendors wash their hands</b>		
No	26	100
Yes	0	0
<b>Was high-risk produce protected</b>		
No	2	8
Yes	24	9
<b>If yes to previous question, How is it protected (N=24)</b>		
<b>Tent</b>		
No	0	0
Yes	24	100
<b>On a table</b>		
No	0	0
Yes	24	100
<b>Plastic or wooden containers</b>		
No	0	0
Yes	24	100
<b>Coolers</b>		
No	20	83
Yes	4	17

**Table 2. Produce handling characteristics of observed farmers' market vendors in Rhode Island**

(N=26) *continued*



	<b>Frequency</b>	<b>Percent</b>
<b>Were high-risk produce sold precut</b>		
No	26	100
Yes	0	0
<b>Were high-risk produce being cut on-site</b>		
No	26	100
Yes	0	0
<b>Were other produce being sold pre-cut</b>		
No	26	100
Yes	0	0
<b>Were other produce being cut on-site</b>		
No	26	100
Yes	0	0
<b>Were high-risk produce being stored on the ground</b>		
No	17	65
Yes	9	35
<b>Were bruises visible on high-risk produce</b>		
No	11	42
Yes	15	58
<b>If yes to previous question, Is it: (N=15)</b>		
Lightly Bruised	15	100
Heavily Bruised	0	0

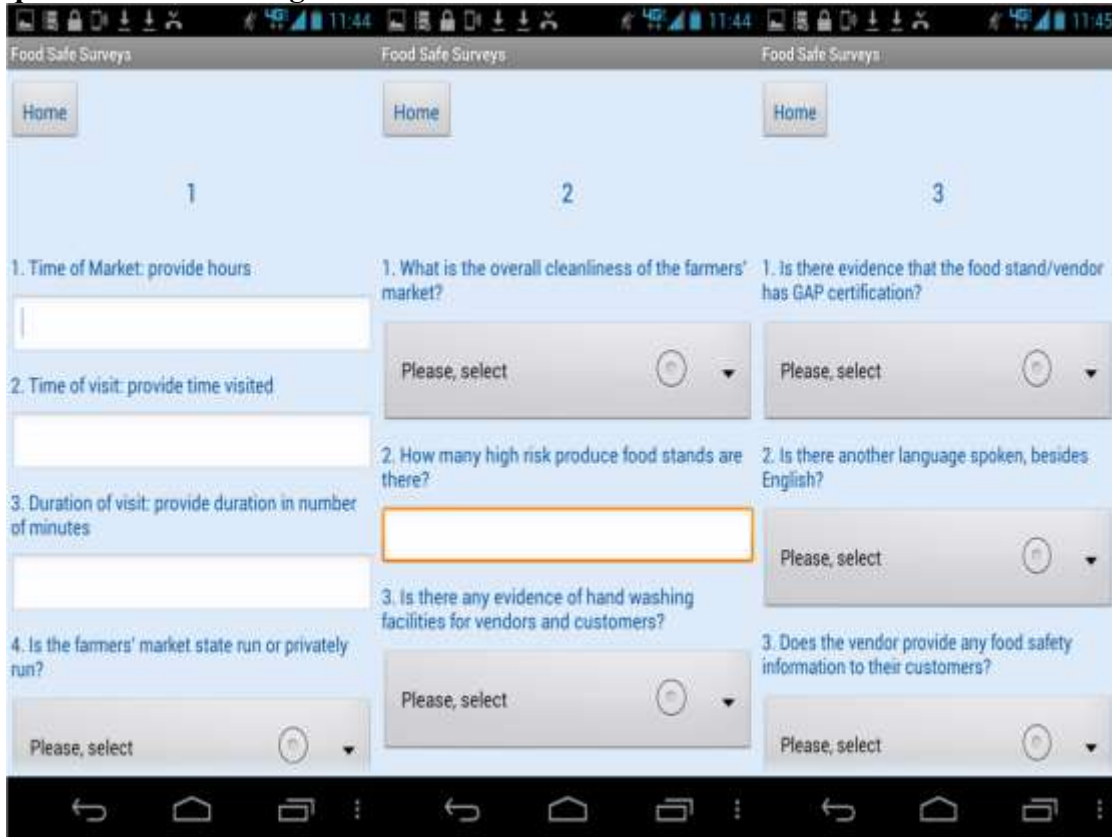
**Table 3. Unsafe produce handling practices observed by farmers' market vendors in Rhode Island (N=26)**

	<b>Frequency</b>	<b>Percent</b>
<b>Leaving the vendor stand unattended</b>		
No	22	85
Yes	4	15
<b>Touching body</b>		
No	24	92
Yes	2	8
<b>Touching money</b>		
No	5	19
Yes	21	81
<b>Eating and/or drinking</b>		
No	18	69
Yes	8	31
Eating	5	
Drinking	5	
<b>Talking on the phone</b>		
No	21	81
Yes	5	19

Note: All observed practices were followed by handling produce with no handwashing between the behaviors.

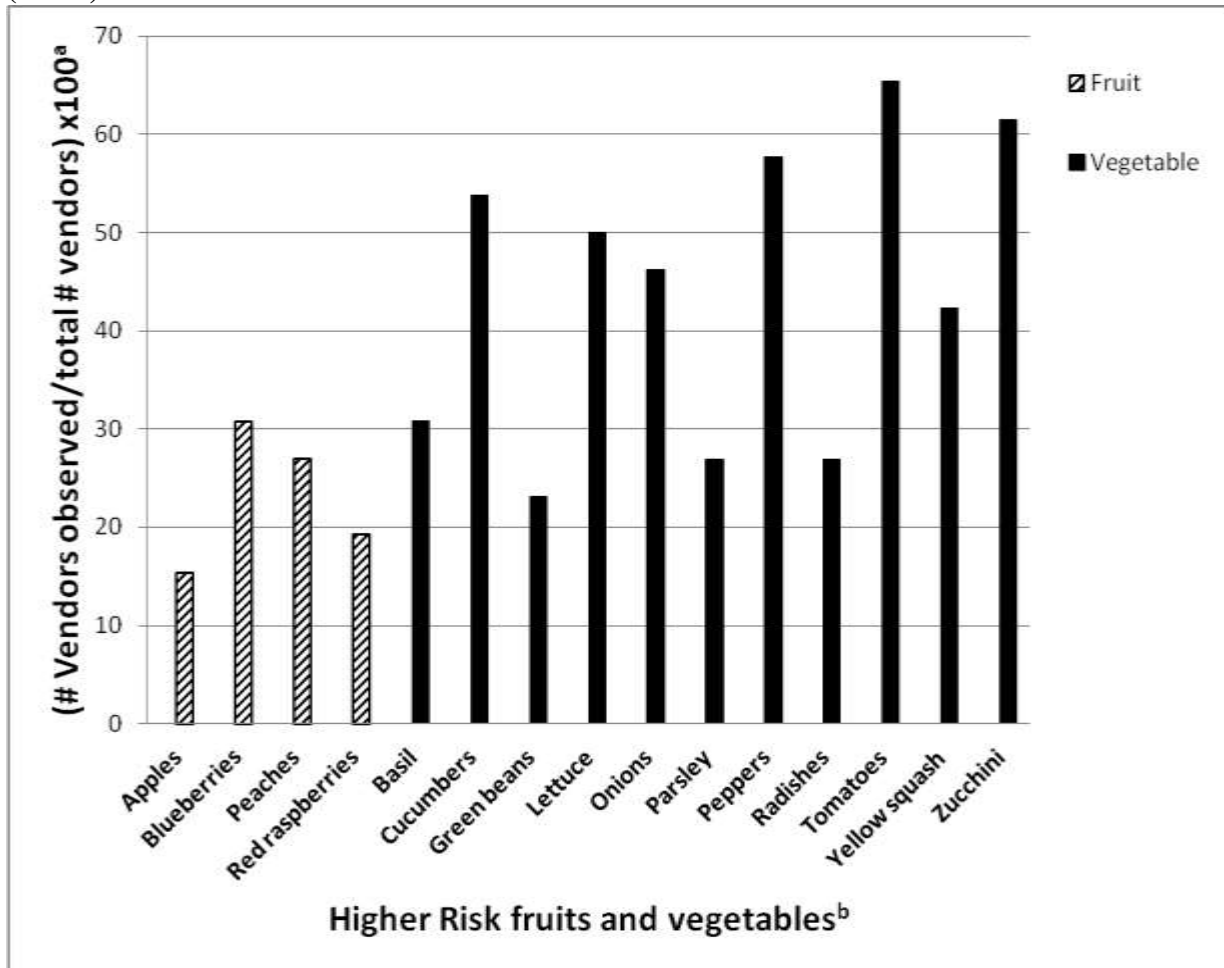
## FIGURES

**Figure 1. Screenshot of the Smartphone Application “Food Safe Surveys” with example questions used during farmers’ market vendor observations**



**Figure 2. Most frequently observed higher risk fruits and vegetables at Rhode Island farmers’ markets**

(N=26)



<sup>a</sup>Note: Reflects (number of vendors observed/total number of vendors) times 100.

<sup>b</sup>Note: Fruits reported if sold by  $\geq 15\%$  vendors and vegetables if  $\geq 20\%$  of vendors.