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6200 Aurora Ave., Suite 200W, Des Moines, IA 50322-2864

Elizabeth G. Vandeputte,[a] Lori F. Pivarnik,[a*] Joshua Scheinberg,[b] Robson Machado,[b] Catherine N. Cutter[b] and Ingrid E. Lofgren[a]

[a]Dept. of Nutrition and Food Sciences, University of Rhode Island, Ranger Hall, Kingston, RI 02881, USA
[b]Dept. of Food Science, The Pennsylvania State University, University Park, PA 16802, USA


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

## ABSTRACT

The number of foodborne illness outbreaks increased in the United States from 2001 to 2010, and 17% of them were associated with produce. Higher risk, whole produce sold at farmers' markets presents unique challenges to food safety practices in regard 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, as a tool for data acquisition, a Smartphone application developed to allow concealed direct observations of actual vendors' practices at farmers' markets. Observations were made at fourteen (7 state and 7 private) farmers' markets to collect data on food handling practices of 26 vendors selling higher-risk produce. The mean observation time per vendor was 18.3 ± 5.8 minutes. Vendors' unsafe food handling practices 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 being detected. The results of this study will be used as guidance for education programs targeting farmers' market managers and vendors that promote best practices in regard to whole produce.

## INTRODUCTION

In 2011, it was reported that approximately 48 million Americans contract foodborne illnesses annually, which is equivalent to one of every six Americans *(27)*. Thirty-one known foodborne pathogens caused 44% of the identified foodborne illness cases that led to hospitalizations and 44% of those that led to death *(27)*. A report from the Centers for Disease Control and Prevention stated that among all reported outbreaks occurring from 1998 to 2008, 46% of illnesses were attributed to commercially sold produce, with leafy green vegetables being more frequently associated with outbreaks than other produce commodities *(18)*. Furthermore, from 1996 to 2010, 131 documented, produce-

* Corresponding author: Phone: +1 401.874.2972; Fax: +1 401.874.2994; E-mail: lpivarnik@uri.edu

related outbreaks were reported, 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 of produce after harvesting, and transportation of produce from the farm *(21)*. In 2010, the U.S. Congress passed the Food Safety Modernization Act, which mandates that the FDA promulgate rules that address food safety during harvesting, processing, and transporting of food and that 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. This proposed rule includes evidence-based standards that identify specific higher risk produce items that are commonly contaminated by pathogens and lead to foodborne illness outbreaks *(35)*.

The consumption of produce in the U.S. increased approximately 20% from 1970 to 2005 *(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 U.S. may reflect an increase in 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.

In the past 20 years, the number of farmers' markets in the U.S. has increased significantly, from 1,755 in 1994 to 8,268 in 2014 *(1, 22)*. Farmers' markets have unique food safety issues, distinct from those faced in a traditional supermarket. Many of these risks are due to environmental factors, since many farmers' markets are located outdoors 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, little research 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. Such observations provide an accurate picture of behavior and allow 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 because of awareness of being observed—can greatly impact the results, making the direct observations less valid *(3, 7, 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 little 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 and self report *(25, 38)*. Mystery shopping has typically involved the use of concealed direct observations with paper-based inspection/checklists that are completed by memorization of the observed behaviors and recording data after the event. This method can result in loss and reduced quality of data 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.

This study focused on the assessment of vendor food handling practices of higher risk produce sold at farmers' markets in Rhode Island (RI), using a mystery shopping protocol. The goal 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, 7, 15, 25, 38)* of vendors at RI farmers' markets, with an Android mobile SA used for primary data collection. The SA was used as a data collection instrument instead of using a 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 was to assess

food handling practices via concealed direct observation by use of an 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 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 on the basis of the RI rural and urban Census Places definitions *(31)*, which delineate several levels of rural and urban populations. A farmers' market was considered rural if the location consisted of a population ≤ 50,000 people and urban if the population was > 50,000 people *(31)*.

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

Using a modified protocol as delineated by Behnke et al. *(3)*, a mobile SA was developed as a data collection tool. Behnke et al. used a Smartphone and SA to capture direct observations of food handling transactions and food safety behaviors of farmers' market employees. Although the study targeted farmers' market vendors, it 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 any produce was processed at the market.

The mobile SA "Food Safe Surveys" was developed at AHG, Inc (300 D. Pugh. St., State College, PA) through collaboration of 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. 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, on both 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 with a high degree of efficiency. 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 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 providing information on 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 items regarding critical and emerging food safety issues pertaining to state regulators' oversight of farmers' markets *(20)*.

The advisory committee members were: the Compliance Evaluation/ Standardization Officer at the Division of Food Protection at RIDOH, Chief of the Office of Food Protection at RIDOH, Chief Division of Agriculture at RIDEM, and Deputy Chief Division of Agriculture at RIDEM. Each member of the advisory group was interviewed separately. On the basis of 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 generally 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 corresponded to the 54 items 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 (1 = unclean and 2 = 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 as clean if the vending table was clear of dirt and visible soiled areas, and if it presented high-risk produce hygienically, in containers that did not contain dirty water. Last, the farmers' market vendor was classified as unclean if the vendor had dirty nails or soiled clothing and 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), based on data produced by the RIDEM "Directory of Rhode Island Farmers' Markets," 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, questions in the second category, reflecting the overall farmers' market environment, were answered (10 questions). The third category, vendor handling characteristics of higher-risk produce, consisted of 37 questions that 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 consisted of the availability of a sign at the vendor stand. Complete observational assessments were made for 1 or 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 without changing overall content. At two farmers' markets, only one vendor could be observed because there was only one higher-risk produce vendor present.

**Farmers' market vendor observations**

Observations of farmers' market vendors were performed between July and August 2013 at 14 RI farmers' markets. One or 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 relatively small 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 sample questions used in the observational assessment.

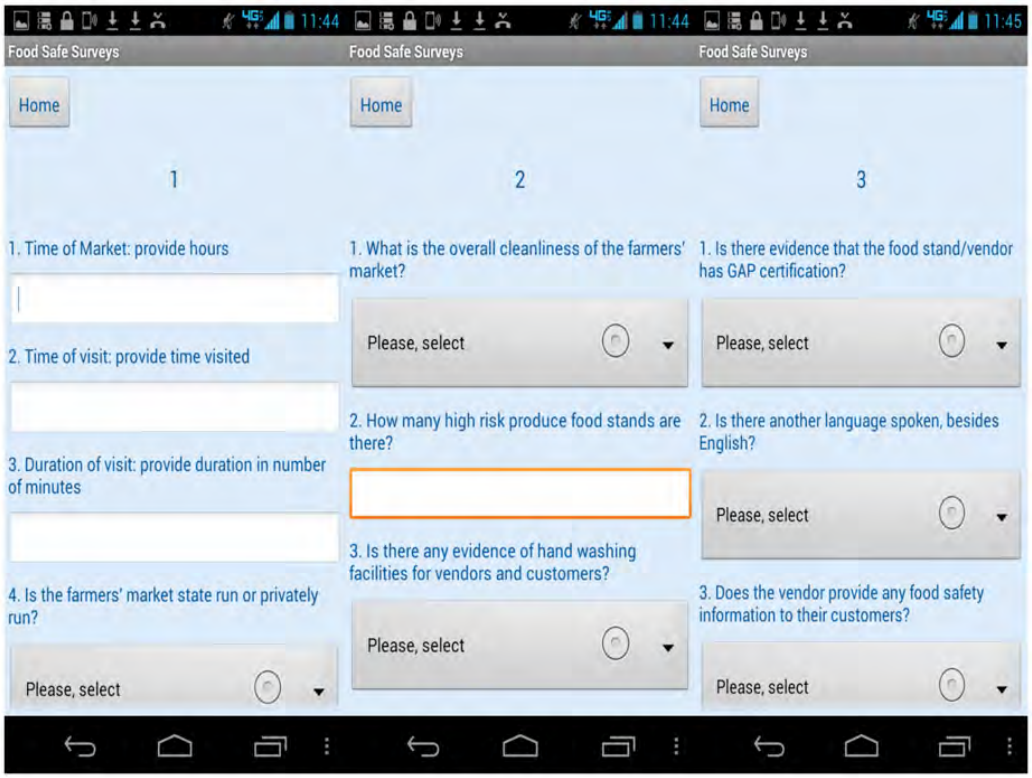



*Figure 1. Screenshot of the Smartphone Application "Food Safe Surveys" with sample questions used during farmers' market vendor observations*

### Data analysis

Data analysis was performed using SPSS version 22.0 for Windows. Descriptive statistics were assessed. Categorical variables were presented as frequencies and percentages, and continuous variables were presented as means ± standard deviations. Chi-square tests or Fisher's Exact test (when the cells had an expected count less than five) were performed to compare results as to (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 tests of statistical significance was set at $P < 0.05$.

## RESULTS

### Demographics

*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 ± 5.8 minutes per vendor. Six farmers' markets had < 4 higher-risk produce vendors present, and 8 had ≥ 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 provided a hand washing facility with both water and soap, available to customers while three provided bathrooms available for customers. Among those markets with bathrooms, two of the bathrooms provided both water and soap and one provided only hand sanitizer.

*Figure 2* shows the frequency at which high-risk produce was present and handled at observed farmers' markets. The most frequently present and observed higher-risk fruits were blueberries (8 vendors, 31%), peaches (7 vendors, 27%), and red raspberries (5 vendors, 19%). The 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 as 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 because the counts were lower than 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 containers, and/or if it was in coolers. Of the 24 vendors that protected their produce, all (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 they were not processing onsite.

While the majority of vendors stored the produce off the ground at the famers' 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 that appeared discolored, and/or had 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.

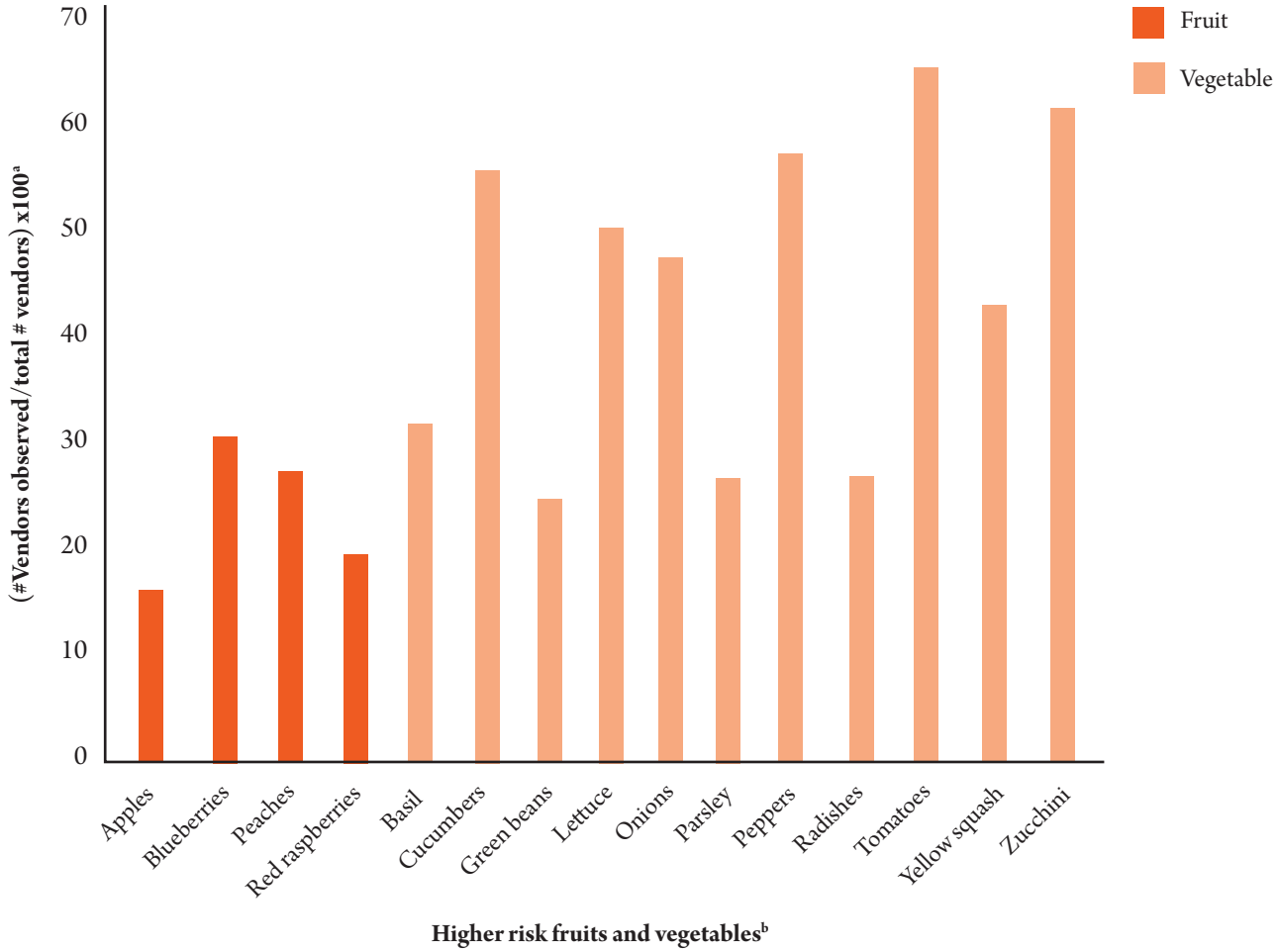
### Vendor handling practices

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, or 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 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 recorded during the observations. Unsafe behaviors were classified as those actions performed by the vendor that could compromise food safety. These included leaving the vendor stand unattended, touching parts of 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 so as to prevent contamination of the employee's hands, the container and exposed food *(24)*, 5 of 8 vendors were also eating food, a behavior that should be done only 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 in between. Eight (32%) out of 26 vendors also ate or drank and then touched produce.

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

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




[a]Reflects (number of vendors observed/total number of vendors) times 100.

[b]Fruits reported if sold by ≥ 15% of vendors and vegetables if ≥ 20% of vendors.

*Figure 2. Most frequently observed higher risk fruits and vegetables at Rhode Island farmers' markets (n = 26)*

## DISCUSSION

This study showed that RI farmers' market vendors had many correct behaviors that would satisfy the requirements of addressing 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. It also showed that vendors rarely distributed food safety information pertaining to the produce to their customers.

Vendors are usually engaged in multiple tasks, a situation that can increase the risk of contamination of produce *(3, 16)*. Vendors were observed touching money (81%) and eating and/or drinking (32%) without washing their hands before touching produce, which increases the 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 they have been 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 the containers used to transport produce from the farms to the markets. The study

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

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

*Continued on next page*

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

| | Frequency | Percent |
|---|---|---|
| **Were high-risk produce sold precut** | | |
| No | 26 | 100 |
| Yes | 0 | 0 |
| **Were high-risk produce being cut on-site** | | |
| No | 26 | 100 |
| Yes | 0 | 0 |
| **Were other produce being sold pre-cut** | | |
| No | 26 | 100 |
| Yes | 0 | 0 |
| **Were other produce being cut on-site** | | |
| No | 26 | 100 |
| Yes | 0 | 0 |
| **Were high-risk produce being stored on the ground** | | |
| No | 17 | 65 |
| Yes | 9 | 35 |
| **Were bruises visible on high-risk produce** | | |
| No | 11 | 42 |
| Yes | 15 | 58 |
| **If yes to previous question, is it: (n = 15)** | | |
| Lightly bruised | 15 | 100 |
| Heavily bruised | 0 | 0 |

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 increase the food safety risk. Similiar studies have also 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 to 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)* which showed infrequent hand washing by vendors and lack of facilities at the markets. Fewer than half of the markets observed had facilities, and even fewer 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 sun, which can indirectly lead to pathogenic microbial infiltration and proliferation when quality is compromised *(29)*. Harrison et al. *(13)*, explained how cooling produce or shading it 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 are exposed to the sun or sit in hot conditions for extended times, resulting in changes

**Table 3. Unsafe produce handling practices of vendors observed in farmers' markets in Rhode Island (n = 26)**

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

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

to produce that could increase the 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 that 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 described 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 appropriateness for use in 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 than when they had no knowledge of being observed. The Hawthorne Effect appeared to be minimized during this study of market vendor behaviors because of the use of the SA in observation of key food safety handling practices.

During the observations of farmers' market vendors, only one vendor was observed to provide 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 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 Survey's 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 in this study because of the ability of Food Safe Surveys

to operate without an Internet connection. Additionally, it is assumed that the SA greatly decreased the Hawthorne Effect, because the observers looked as though they were texting on a Smartphone, a very common occurrence. This study also had an increased sample size and specifically examined handling practices of produce, compared with 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 were observed to perform 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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