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FOOD TRACEABILITY IN SCHOOL FOODSERVICE OPERATIONS: BENEFITS AND CHALLENGES

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ABSTRACT

Purpose/Objectives

This study explored food traceability systems in school foodservice in the United States and the potential benefits and challenges to their implementation.

Methods

An online questionnaire was developed and used to collect data. A mixed-mode approach was followed to recruit the participants. A convenience sample of 500 school nutrition professionals from Qualtrics® panel was targeted for data collection with the goal of having responses from 300 participants. Due to low response rate from the initial panel, the contact information of a second convenience sample of 200 child nutrition professionals with no geographic representation was obtained from the National Center for Education Statistics database. The individuals were invited to participate by email with a link to the questionnaire. Data was analyzed using SPSS. Descriptive statistics were computed to screen and summarize the data. Factor analysis was performed to categorize and identify potential benefits of, and challenges to implementing food traceability systems in school foodservice.

Results

A total of 427 respondents accessed the questionnaire. Only 124 completed questionnaires were retained for a response rate of 24.8%. The findings showed that traceability systems in the investigated districts involve either paper-based or manually entered data systems. The top identified benefits of implementing food traceability systems were supporting food safety, preventing bioterrorism, and cost reduction. Among the top reported challenges to implementing food traceability systems were the unexpected substitution of food by vendors and high cost of implementing advanced traceability systems.

Applications to Child Nutrition Professionals

The results of the study suggested that school nutrition authorities need to continue to document and track their food supplies to ensure food safety in all stages of production, processing, and service in their districts. School foodservice operations are also encouraged to implement a traceability system that is compatible with the food products, the production process, and budget in order to respond effectively to food-related incidents and protect safety of food served.

Key words: Food traceability, food safety, school foodservice, traceability systems.

INTRODUCTION

Food traceability can be defined as the ability to access all information related to a food product through its entire life by means of recorded identifications (Olsen & Borit, 2013). The overarching purpose of food traceability systems is to facilitate the identification of affected products due to a food safety incident, and improve the ability to withdraw or recall such products and prevent them from reaching the customers (The National Food Service Management Institute, 2012b)

Food traceability systems are based on four components: product identification and process linking, data to trace, product routing and data retrieval, and traceability tools (Folinas, Manikas & Manos, 2006; Regattieri, Gamberi & Manzini, 2007). Depending on the complexity of the supply chain, the traceability systems can be either paper-based with manual entry of data or information-technology based. Optical systems like barcodes, radio frequency identification tags, time temperature indicators, and laser etchings on edible labels of fruits and vegetables are commonly adopted traceability information carriers (Kros, Richey, Chen, & Nadler, 2011; Kück, 2006; Lee & Park, 2008; Sauvage, 2003). As a minimum, traceability information should include quality attributes, weight, volume number, and time and location of harvest (Kumar, Heustis, & Graham, 2015).

The United States Department of Agriculture [USDA] (2017a, 2017b) estimated that almost 14.5 million children were served breakfast, and about 30.4 million students were served lunch each day in 2016. The USDA provides approximately 15% to 20% of the food used in schools through its Food Distribution Program (USDA Food and Nutrition Service, 2016). Because of the amount of food provided, the USDA has implemented procedures to track recall information. The National Food Service Management Institute (2012a) reported that the USDA Food and Nutrition Service notifies state agencies and school nutrition authorities about recalls involving USDA supplied foods to rapidly track and remove these foods from the market. However, the flow of recall information differs for local authorities who independently procure the remaining 80% to 85% of foods used in school breakfast and lunch programs from commercial vendors. Methods such as email and school media are used by USDA Food and Nutrition Service to alert school nutrition authorities of a recall involving non-USDA foods (The National Food Service Management Institute, 2012a). Some commercial food vendors use Global Trade Item Number (GTIN) on cases of food products to identify and communicate products information with schools, which enables tracking capabilities in case a foodborne illness occurs (The National Food Service Management Institute, 2012b).

The need for tracing and tracking food products has gained attention since the terrorist attacks in 2001 (The National Food Service Management Institute, 2012b). The Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (also known as the Bioterrorism Act) was signed into law following the aftermath of the September 11, 2001 terrorist attacks to protect the U.S. food system against further acts (Applebaun, 2004). Food defense measures designed to protect food from intentional contamination can be aided by food traceability systems, which help remove foods from service if they have been contaminated, either intentionally, or unintentionally (Pannell-Martin & Boettger, 2014). Schools are required under the National School Lunch Act to develop a food safety program based on Hazard Analysis and Critical Control Points (HACCP) principles to control food safety hazards (USDA Food and Nutrition Service, 2005). However, Fredrickson (2014) indicated that implementing HACCP is only the first step to reduce intentional contamination in a well-defended food system. Therefore, traceability can be necessary to supplement any preventative measures for potential deliberate contamination (Marmiroli et al., 2011).

The purpose of this study was to explore the existence and procedures of food traceability systems in school foodservice operations. Specific objectives were to (a) identify the status of food traceability systems in schools, (b) investigate benefits of implementing traceability systems in schools as perceived by nutrition program administrators, and (c) determine their perceptions of challenges to implementation of these systems in schools.

METHODOLOGY

Data Collection and Survey Procedures

The data was collected using a self-administered questionnaire that was developed based on previous studies in food traceability in supply chains (Mai, Bogason, Arason, Árnason, & Matthíasson, 2010; Miao, 2010; Xiaoshuan, Jian, Feng, Zetian, & Weisong, 2010). New questions were developed and added to address the context of school foodservice operations.

Two researchers familiar with food safety, traceability systems, and school nutrition programs reviewed the questionnaire for face validity and questionnaire wording. The research protocol involving human subjects was reviewed and approved by the university Institutional Review Board prior to collecting any data. A pilot test was conducted online with 20 local school foodservice directors to check the wording of questions and the reliability of the scales. Based on the results of the pilot test study, minor changes in the questionnaire design and wording were made, including the deletion of a few items that seemed redundant to the respondents.

The final version of the questionnaire included 14 questions about operational information and demographics. A filtering question was utilized to screen out respondents who were not currently employed in a school foodservice operation. The first question asked participants to rate the perceived degree of completeness of the current traceability system in their school district using a scale from 0 (incomplete) to 10 (complete/comprehensive). The second question included 11 items and an open-ended response option to ask participants about their opinions on the benefits of implementing a traceability system. The third question included 12 items and an open-ended response option to ask about the potential challenges of implementing a traceability system. Both the second and the third questions used a 5-point Likert-type rating scale (1 = strongly disagree and 5 = strongly agree) adopted with modifications from Mai et al. (2010), Miao (2010), and Xiaoshuan et al. (2010). Question 4 asked about priority assigned by district administration to implement a traceability system using a scale from 0 to 10 (with 0 to 3 = very low priority, and 8 to 10 = high priority). Question 5 was an open-ended question that asked the number of times food was traced back per school year. Questions 6 to 11 asked about current methods of traceability utilized, food items which are tracked, number and types of meals served in the district, and whether there was a person designated to oversee food traceability. The last three questions of the survey asked for respondents' demographics including gender, position, and number of years of work experience in school nutrition programs.

Sample

The final version of the questionnaire was posted using Qualtrics®, an online survey platform. A mixed-mode approach was followed to recruit participants. First, a national convenience sample of 500 school nutrition professionals from Qualtrics® panel was targeted for data collection with the goal of having responses from 300 participants. Due to the low response rate from the first panel, the National Center for Education Statistics (NCES) database was used to search for school nutrition professionals' contact information, from which a second convenience sample of 200 child nutrition professionals with no geographic representation was drawn. The contact information of the potential participants on the NCES database was verified using the websites of the corresponding school districts. The goal was to draw a national convenience sample regardless of size of districts. The researchers invited these child nutrition professionals to

participate via email with a link to the questionnaire. Follow-up reminders were emailed three days after sending the invitational emails to prompt non-respondents to complete the questionnaire.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) for Windows (version 23, 2015, IBM, Inc., Chicago: IL) was used to analyze data. Descriptive statistics including frequencies, means, and standard deviations were computed to summarize and screen the data. Exploratory factor analysis using principal components extraction and varimax rotation was performed to help categorize and identify reported benefits of and challenges to implementing food traceability in schools. A minimum Eigenvalue criterion (Eigenvalue > 1) was used to retain the factors, with a minimum loss of information and the proportion of variance explained.

RESULTS AND DISCUSSION

Profile of Respondents

The demographic characteristics of the respondents are displayed in Table 1. A total of 427 respondents from both mailings accessed the questionnaire. Of the 427 respondents who began the questionnaire, 237 were not school nutrition professionals and did not pass the filtering question, while another 66 started the questionnaire, but did not complete it. To be included in data analysis, respondents had to complete greater than 80% of the questionnaire, which would include all questions up to the demographic questions. Only 124 usable questionnaires were completed for a response rate of 24.8%. Slightly more than half the respondents were females (51.6%) and approximately half the respondents indicated their title was a foodservice director (44.4%).

Table 1. *Profile of Respondents (N = 108-110)*

Characteristic	*N*	*%*
Gender		
Male	44	35.5
Female	64	51.6
Position		
Foodservice Director	55	44.4
Assistant Foodservice Director	27	21.8
Cafeteria Manager	18	14.5
Food Safety Coordinator	7	5.6
Other	3	2.4
Years employed in school foodservice		
5 years or less	54	43.5
6- 15 years	38	30.6
16- 25 years	12	9.7
26 years or more	4	3.2

Note. Totals do not equal 124 and percentages do not equal 100% due to missing data.

Meals Served in the Investigated School Districts

The results regarding the meals served in the investigated school districts indicated that of those who responded, 90% served lunch and 81.8% served breakfast. An equal percentage of respondents indicated that they served morning and afternoon snacks (22.7%). A few respondents served dinner (6.3%) and 5.5% served an evening snack.

Perception of the Completeness of Food Traceability Systems in Schools

The results showed that the current food traceability systems in the responding school districts were perceived to be partially complete (4-7; 54.9%), complete (8-10; 36.3%), or incomplete (0-3; 8.8%). Slightly more than half of the respondents (52.4%) ranked the development of an effective traceability system in their schools as a medium priority (rating of 4 to 7) and 37.9% of the respondents indicated it was of a high priority (8 to 10). The majority of the respondents (62.9%) indicated that there is a primary person who oversees food traceability in their districts. Although schools are not required under the Bioterrorism Act of 2002 to have forward traceability procedures, it is still important to identify the source of food served using real-time information to respond effectively to food safety incidents, like recalls (Pannell-Martin & Boettger, 2014). Duan, Miao, Wang, Fu, and Xu (2017) indicated that managerial support and commitment of all functional segments of an organization are critical to ensure high priority is given to the implementation of traceability systems. Thus, school nutrition authorities are encouraged to continue to prioritize food traceability and ensure the credibility and completeness of traceability information to protect the safety of food served.

Traceability Systems Used in the School Districts

The findings showed that 38.3% (n = 82) of the respondents used a paper trail to document and record the history of the food. About half the respondents used manually entered data which was electronically stored, and barcodes as the traceability systems in their districts (27.1%, n = 58) and (25.2%, n = 54) respectively. Other methods identified to track food included radio frequency identification tags (4.7%, n = 10), combined radio frequency identification and time-temperature indicator systems (3.3%, n = 7), and other procedures such as labels on shipments or information provided by suppliers (1.4%, n = 3). The limited usage of radio frequency identification tags and time-temperature indicators could be attributed to the high cost of implementing such systems (Xiaoshuan et al., 2010).

Frequency of Tracing Back and Types of Most Frequently Traced Back Foods

Responding school districts estimated, that on average, food was traced back 9.2 times (*SD* = 18.4) per school year. The range was 0 to 150 times, and six respondents reported that they had not traced back food at all. Only one respondent indicated that they had traced back food an estimated 150 times during the school year given their district size. Table 2 shows the percentages of districts identifying types of food items that were most frequently traced back. Approximately, 18.8 % of districts responding indicated that milk and dairy products were most frequently traced food items, followed by pre-cooked fish and shellfish (18.5%), and fresh fish and shellfish (15.1%). The high percent of fish items was linked to respondents from school districts located in areas where harvested fish is abundantly available, and which served locally caught fish, fish products, and shellfish in their cafeterias. The lowest percentage was for raw meat and poultry (1.7%). Several school districts serve milk that is sourced from local dairies due to perishability of the product and the cost of shipping (USDA Food and Nutrition Service, 2015). Other dairy products like cheese are typically purchased commercially or sourced by the USDA (USDA Food and Nutrition Service, 2016). Although contamination, adulteration, and misbranding were the major reasons for food recalls, undeclared allergens such as milk and shellfish were potential culprits for recalls (White-Cason, 2013). During the calendar year of 2017, when data collection for this study was initiated, the total number of recalls by USDA was 131, including 53 recalls due to undeclared allergens followed by 24 recalls due to extraneous materials (USDA Food Safety and Inspection Service, 2017).

Table 2. *Percent of Reported Food Items Traced Back per School Year by Type*

Food Items	***N***	***%***
Milk and dairy products	56	18.8%
Pre-cooked fish and shellfish	55	18.5%
Fresh fish and shellfish	45	15.1%
Canned fruits	28	9.4%
Canned vegetables	27	9.1%
Fresh fruits	20	6.7%
Dried commodities (rice, pasta, beans, etc.)	18	6.0%
Fresh vegetables	12	4.0%
Other	12	4.0%
Baked products	11	3.7%
Pre-cooked meat and poultry	9	3.0%
Raw meat and poultry	5	1.7%

Note. The total number of responses exceeds 124 as respondents were asked to select all foods that were traced back.

Factor Analysis for Potential Benefits of Implementing Food Traceability Systems

The results of exploratory factor analysis are shown in Table 3. The data was checked for normality using the **Kolmogorov-Smirnov test and Q-Q plots and** found non-normally distributed. Therefore, a principal component analysis was conducted with varimax rotation on the 11 items related to the potential benefits of implementing traceability systems in school foodservice. The Kaiser-Meyer-Olkin (KMO) value was 0.89, which exceeded the cut-off value of 0.50, and the Bartlett's test of Sphericity was significant ($p < 0.001$) indicating sufficient sampling adequacy for factor analysis (Hutcheson & Sofroniou, 1999).

Based on the minimum eigenvalue criterion (eigenvalue > 1), two factors were retained and they explained approximately 58% of the variance. The subscales of the two factors demonstrated good internal reliabilities with the first factor Cronbach's $\alpha = 0.86$, and the second factor Cronbach's $\alpha = 0.76$, which exceeded the cutoff point of 0.7 (Nunnally & Bernstein, 1994). Factor one was labeled "improved food safety and recall", and factor two was labeled "cost reduction, compliance, and meeting expectations." Based on factor analysis, the results of factor one suggested that traceability systems could be used as tools to improve food safety through facilitating backward and forward tracking capabilities. The results also suggested that other potential benefits of implementing traceability perceived by the respondents were improving knowledge of food origin, and providing sufficient nutrition and allergy information. According to the National Food Service Management Institute (2012b), school foodservice operations may take advantage of traceability initiatives offered by major food manufacturers like the use of Global Data Synchronization Network (GDSN) to synchronize product information including nutrition and allergens. Based on factor analysis, factor two suggested that reducing labor and production costs seemed to be other potential benefits of implementing a traceability system. Therefore, if a food safety problem were to occur, food could be traced one-step backward through the food chain to recall the affected products effectively (Pascu, 2013).

Table 3. *Exploratory Factor Analysis Results for 11 items Regarding Perceived Benefits of Implementing Food Traceability Systems*

	Rotated Factor Loadings	
Variables	**Factor one**	**Factor two**
Reducing risk of foodborne diseases outbreaks	0.773	
Reducing risk associated with a bio-terrorism incident	0.735	
Improving knowledge of origin of food ingredients	0.726	
Providing sufficient nutrition and allergy information about food	0.696	
Improving product quality	0.659	
Protecting food safety by effective product recall	0.594	
Improving stock management	0.570	
Reducing labor cost		0.861
Reducing production cost		0.764
Complying with relevant legislations		0.615
Meeting the expectations of students/students' parents		0.515
Eigenvalues	5.31	1.07
Variance explained	48.32%	9.75%
Cronbach's Alpha	0.86	0.76

Factor Analysis for Challenges to Implementing Food Traceability Systems

Factor analysis with a varimax rotation was conducted on 11 items related to potential challenges of implementing food traceability systems in schools (Table 4). Two factors were retained and explained 85.65% of the variance. The subscales of the two factors had acceptable reliability (Cronbach's Alpha = 0.74 and 0.71 for the first and the second factors respectively).

Table 4. *Exploratory Factor Analysis Results for 10 Items Regarding Perceived Challenges to Implementing Food Traceability Systems*

	Rotated Factor Loadings	
Variables	**Factor one**	**Factor two**
Unexpected substitution of food by vendors	0.688	
Lack of organizational commitment to traceability implementation	0.631	
High cost of implementation	0.615	
Lack of standards regarding traceability information	0.578	
Lack of knowledgeable staff	0.556	
The need for additional storage space		0.624
Ensuring the adequacy and validity of traceability information		0.594
Increased price of traceable food charged to students		0.575
The need for increased education and training of staff		0.503
Lack of government funding for the implementation of food traceability systems		0.489
Eigenvalues	3.23	0.94
Variance explained	66.34%	19.31%
Cronbach's Alpha	0.74	0.71

The first factor was labeled as “technical and financial challenges”, and the second factor was labeled as “operational challenges”. These results agree with the previous studies in commercial food chains that found that application of food traceability could be difficult due to the high cost of implementation for some advanced traceability systems, and lack of uniformity in the traceability systems used (Kher et al., 2010; Xiaoshuan et al., 2010). Although computerized inventory tracking systems are common in school districts, the cost of electronic traceability of food products may be high for some school districts to afford given the limited financial resources available (School Nutrition Association [SNA], 2017). Governmental support regarding funding, technology, and equipment is crucial for the implementation of traceability in schools. With sufficient funding, the government can take the necessary steps in fulfilling the traceability standards suggested in the Food Safety Modernization Act of 2011.

CONCLUSIONS AND APPLICATION

Application to School Nutrition Professionals

Although research has been done on the development and implementation of food traceability systems in agribusiness, there is a paucity of research that explored traceability systems in the school setting in the United States. Because the recall communication process between school districts and vendors can be complex due to the high volume of food served in schools, the impact of serving a recalled product could have devastating consequences on children, local communities, and the National School Lunch Program. Foodborne illness in schools tends to be a local problem due to improper food handling and cross-contamination (Martins & Rocha, 2014). While foodborne outbreaks are rare in schools, when an outbreak does occur, more foodborne illnesses result due to the high average number of meals served. For instance, Venuto, Garcia, and Halbrook (2015) indicated that school foodborne outbreaks from 2000 to 2010 accounted for about 3.8% (n = 464) of all outbreaks reported to the Centers for Disease Control and Prevention and resulted in 20,667 illnesses. In one large-scale outbreak that involved the National School Lunch Program, frozen strawberries that contained Hepatitis A resulted in 242 illnesses among students and employees in 1997 (Hutin et al., 1999). Therefore, the purpose of this study was to explore food traceability systems in school foodservice operations by identifying the status of food traceability in school districts, and investigating the perceived benefits and the potential challenges pertaining to implementation of such systems. The results supported that traceability systems could be used as tools to facilitate trace-back and trace-forward capabilities in the school food supply chain to promote food safety and biosecurity efforts. Similarly, Nunnelley (2012) surveyed a sample of 411 child nutrition professionals from school districts in North Carolina, South Carolina, and Georgia. The researcher found that one of the benefits perceived by the respondents regarding the implementation of a traceability system was decreasing the recall time, and the impact of a foodborne illness outbreak. The findings of the current study are also in line with those of Chrysochou, Chryssochoidis, and Kehagia (2009), in that the effective implementation of a traceability system helps ensure product authenticity and credibility of product information. The results of this study also suggested that the respondents perceived traceability systems to help reduce costs of the recall process, and the food waste associated with collection and disposal of affected/contaminated food products. Therefore, to reap the full benefits of food traceability, school nutrition authorities are recommended to review the completeness of their food traceability systems by ensuring their ability to identify the source of food items effectively, capture and retrieve the information accurately, and share the information with partners in the supply chain in a timely manner. School nutrition professional may also conduct a mock recall with vendors to test the effectiveness of their internal traceability systems (Institute of Child Nutrition, 2016)

The findings suggested that the application of food traceability could be difficult due to the high cost of implementation, especially for some information technology-based traceability tools such as radio frequency identification tags. Limited financial resources and the rising costs of food and labor may contribute to the challenges of implementing traceability systems given that there are about 13,600 public school districts (U.S. Department of Education, NCES, 2017), and more than 99,000 schools participating in the National School Lunch Program and more than 90,000 sites participating in the School Breakfast Program in the U.S. (SNA, 2017). Regardless of the challenges to implementing a food traceability system in schools or upgrading to a more advanced system, school nutrition professionals are recommended to continue to document and track the supply of food in their districts to ensure food safety in all stages of production, processing, and service. There is a wide array of traceability systems, each of which has advantages and disadvantages based on cost and the technology requirements. These range from paper-based to advanced electronic systems. The food traceability information can be made available through a virtual traceability network using either a third-party solution provider or the school districts' own databases. Thus, the ultimate choice of a traceability system should reflect its compatibility with the food product, the district's food production processes, as well as the standardization of the system along the supply chain (Regattieri et al., 2007).

The results of factor analysis regarding the challenges to implementing food traceability systems indicated that operational challenges like unexpected substitution of food by vendors may hinder the implementation of traceability. To implement traceability systems efficiently and identify affected products accurately when recalls occur, substitutions should be clearly defined in solicitation documents for both formal and informal purchasing methods (Institute of Child Nutrition, 2015). This practice is also good for tracking special diets such as allergens, and for standardization of recipes to ensure product consistency.

The results indicated that overall, the investigated school districts lack the use of information technology-based traceability systems. School nutrition authorities, vendors, and other partners in the supply chain may need to collaborate to identify investment solutions, costs, and benefits associated with the implementation of these advanced systems. District buyers are also recommended to specify trace-back capabilities in the language of their bidding documents (Institute of Child Nutrition, 2015). For instance, bids and purchasing documents should specify selection criteria for distributors including documentation and recordkeeping to enable traceability one step back and one step forward (Institute of Child Nutrition, 2016). Kumar et al. (2015) elucidated that technology-based traceability tools like radio frequency identification tags present more favorable features for food traceability in terms of carrying more information than barcodes. However, traceability systems using radio frequency identification tags may not be affordable by some school districts.

The findings also showed that the most frequently traced back food items were milk and dairy products, pre-cooked fish and shellfish, and fresh fish and shellfish. School nutrition professionals should continue to document information on their menus and production records to allow for trace back of any affected items to the purchasing records in case there is a recall. School nutrition professionals are also recommended to avoid mixing food items from different suppliers in storage, preparation, or service areas. This will help trace any affected products back effectively to specific suppliers in case there was a recall or a food safety incident and avoid unnecessary waste and higher food costs by disposing of similar unaffected products from other suppliers or vendors.

Future Research

This study expanded our knowledge on the benefits and challenges to implementing food traceability systems in schools. The findings of this study provided practical implications for

school nutrition authorities and associated agencies to identify the potential of promoting current traceability systems to support food safety and defense, and respond effectively to recalls. This study was conducted online with a convenience sample of school nutrition professionals in the U.S., so the generalizability of the findings is limited. Because some of the respondents may have showed social desirability bias given the self-report nature of the survey instrument, the results should be considered within the context of this study. The results of this study showed that the high cost of implementing information technology-based traceability systems is one of the challenges. Future research could focus on a cost-benefit analysis of using information technology-based food traceability systems in school foodservice. Future research is also encouraged to investigate the degree to which local school nutrition authorities fully exploit the potential benefits of their current food traceability systems. Research is also needed to investigate traceability systems and assess the level of their implementation in other on-site or commercial foodservice settings in order to gain insights and provide guidance for operators or managers considering investment in food traceability systems.

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