ASSESSING *LISTERIA MONOCYTOGENES* CONTAMINATION RISK USING PREDICTIVE RISK MODELS AND FOOD SAFETY CULTURE MANAGEMENT IN RETAIL ENVIRONMENTS

by

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For my friends, near and far – you hold special place in my heart

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DISCLAIMER

All studies included in this dissertation are published manuscripts. We have obtained permission from the journal, *Food Control*, to reuse these original articles for dissertation purpose. References to the studies in this dissertation are:

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For "Predictive risk models combined with employee- and management-implemented SSOPs identified and reduced *Listeria monocytogenes* prevalence in retail delis" (Chapter 2), I performed statistical analyses, analyzed PFGE pulsotypes, revised preliminary results obtained by Susan Hammons, and wrote the manuscript. I share co-first-authorship with Susan Hammons for this study.

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For "Infrastructure, sanitation, and management practices impact *Listeria monocytogenes* prevalence in retail grocery produce environments" (Chapter 4), I developed, implemented, and collected the surveys, performed statistical analyses, and wrote the manuscript.

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LIST OF ABBREVIATIOINS

ATP:	adenosine triphosphate
BHI:	Brian Heart Infusion
CDC:	Centers for Disease Control and Prevention
DC-SSOP:	deep-clean sanitation standard operating procedure
FAO:	Food and Agriculture Organization
FCS:	food-contact surface
FDA:	Food and Drug Administration
FSIS:	Food Safety and Inspection Service
FSMA:	Food Safety Modernization Act
NFCS:	non-food-contact surface
PFGE:	Pulsed Field Electrophoresis
QAC:	quaternary-ammonium-compounds
RTE:	ready-to-eat
SSOP:	sanitation standard operating procedure

ABSTRACT

Retail environments are critical transmission points for *Listeria monocytogenes* to humans. Past studies have shown *L. monocytogenes* contamination varies widely across retail environments. *L. monocytogenes* can transmit among environmental surfaces and subsequently from environment to food via cross-contamination. Modified SSOPs (sanitation standard operating procedures) have been shown to have limited impact on reducing *L. monocytogenes* prevalence in retail deli environments. Food safety culture and climate, such as beliefs, values, and hygiene behaviors, have been identified as factors impacting food safety performance and microbial outputs. Handwashing and its compliance are among the most prominent personal hygiene aspects subjected to investigation in the past decade, illustrating hygiene behavior as a risk factor and an important consideration to ensure food safety. Additionally, effective management and well-designed infrastructure, such as vertical and lateral communication, employees' training, accountability, and equipment designed to prevent cross-contamination, have also been described as critical contributors to a sustainable food safety program. However, given such a deadly foodborne pathogen as *L. monocytogenes*, the correlation between food safety culture and its prevalence remains unknown. We hypothesized that there was a relationship among food safety culture management, infrastructure, and *L. monocytogenes* prevalence at retail. Our goal is to identify additional risk factors on *L. monocytogenes* control, develop feasible recommendations, and direct resources to enhance food safety.

In the present dissertation, we developed and implemented a predictive risk model, along with employee- and management-implemented SSOPs, in 50 deli establishments across six U.S. states to evaluate and control *L. monocytogenes* contamination risk and prevalence (Chapter 2). The predictive risk model, based on logistic regression, uses five environmental sites to predict *L. monocytogenes* prevalence in the entire deli environment. It identified 13 high-risk stores, seven of which were confirmed during subsequent monthly sampling. We found that deep clean intervention reduced *L. monocytogenes* prevalence on non-food contact surfaces both immediately after the intervention and during follow-up, with marginal significance (α_{adj}=0.0125). The employee- and management-implemented deep clean can control *L. monocytogenes* prevalence in retail delis; the predictive risk model, though conservative, will require further validations and can be useful for surveillance purposes.

Complementary to the above study, we tackled the *L. monocytogenes* challenge via food safety culture and climate approach (Chapter 3). Concurrently to the monthly environmental sampling, we distributed food safety culture and climate survey to the 50 stores, with one manager and up to five associates from each establishment, over a 12-month period and overlapped with before, after, and follow-up deep clean. We found that stores with lower *L. monocytogenes* contamination risk had better food safety culture, including greater sense of commitment to food safety program (p_{adj}=0.0317) and more complete training (p_{adj}=0.0117). Deep clean improved managers' (p_{adj}=0.0243) and associates' (p_{adj}=0.0057) commitment to food safety. This study indicates that food safety culture and climate are crucial component in building a viable, sustainable food safety program.

Another survey tool was used to evaluate infrastructure designs, management strategies, and sanitation practices in relation to *L. monocytogenes* control in retail produce environments (Chapter 4). We distributed the survey to 30 retail produce departments across seven U.S. states. Hand hygiene, minimizing cross-contamination, and maximizing equipment cleanability were the most prominent factors in *L. monocytogenes* control.

CHAPTER 1. *LISTERIA MONOCYTOGENES* CONTROL AND RISK ASSESSMENT AT RETAIL: A LITERATURE REVIEW

Listeria monocytogenes is among the leading causes of foodborne illness related death in the U.S., responsible for approximately 1600 listeriosis cases annually with a mortality rate of 16% (CDC, 2020a; Scallan et al., 2011). While *L. monocytogenes* is ubiquitous, 99% of listeriosis cases are traced back to consumption of contaminated food (Scallan et al., 2011), with both ready-to-eat (RTE) food and fresh produce being high risk (CDC, 2019). Among the deadliest *L. monocytogenes* outbreaks is in 2011 that linked to whole cantaloupes, which caused 143 hospitalizations and 33 deaths across 28 U.S. states (CDC, 2012). A most recent *L. monocytogenes* outbreak in March 2020 is linked to Enoki mushrooms, and has so far caused 30 hospitalizations and 4 deaths (CDC, 2020b). *L. monocytogenes* has been found in diverse environments, including food processing facilities (Carpentier & Cerf, 2011; Ferreira, Wiedmann, Teixeira, & Stasiewicz, 2014), farms (Nightingale et al., 2004), and home environments (Evans & Redmond, 2015). Retail environment is identified as critical transmission point for *L. monocytogenes* (Buchanan et al., 2017; Pouillot et al., 2015; Wang et al., 2015), suggesting the necessity to identify and characterize risk factors for *L. monocytogenes* control at retail.

Some but not all retail delis are prevalent with *L. monocytogenes* (Simmons et al., 2014; Etter et al., 2017), with nonfood contact surfaces having higher prevalence than food contact surfaces (Hoelzer et al., 2011; Simmons et al., 2014; Etter et al. 2017). Cross-contamination has been identified as a key mechanism for the pathogen's transmission (Etter et al., 2017). Multiple intervention studies have been done to control the prevalence and persistence of *L. monocytogenes* at retail, however they have mixed outcomes. According to Etter et al., (2017), their daily Sanitation Standard Operating Procedures (SSOPs) did not reduce *L. monocytogenes* prevalence in the enrolled 30 retail delis. Among the delis of >10% L. monocytogenes prevalence, there was conversely an increase in prevalence after the deep cleaning (Etter et al., 2017). In a follow-up study by Hammons et al., (2017), the third party executed deep clean SSOPs (DC-SSOPs) significantly reduced *L. monocytogenes* prevalence in delis of historically high prevalence (>10%), yet had mixed results eliminating the persistent strains. These results indicate additional factors may be relevant in *L. monocytogenes* control.

Food safety culture has been discussed as a pivotal risk factor in foodborne pathogen surveillance and control. It directly links to microbial outputs, taking in account of context, management, awareness and more that contribute to the entirety of the food safety environment (De Boeck et al., 2015). Although food safety culture is a relatively new concepts, defined in 2015 by De Boeck et al., factors pertaining to food safety culture have been studied throughout the decade. Hand hygiene, among the early investigated aspects of food safety culture, was found to have very low compliance among food handlers (Lubran et al., 2010; Strohbehn et al., 2008), a significant percentage of whom performed handwashing without following the Food Code procedure (Lubran et al., 2010). According to Lee et al. (2017) and Al-Shabib et al., (2016), food safety knowledge did not readily translate into action. The gap in between was explored by Pilling et al., (2008), in which the Theory of Planned Behavior was applied to elucidate factors associated with foodservice employees' intentions behind their actions. They found that more positive attitude to food safety concurred with greater intention to commit food safety behaviors (Pilling et al., 2008). This food safety culture approach to resolve food safety issues was further confirmed by Powell et al., (2013), that top-down food safety audits and inspections are "never enough" for sustainable food safety improvement. Therefore, it is possible that the food safety culture dynamics completed our previous deep clean interventions by enabling a sustainable food safety program that is embedded among the employment structure.

In the presented three studies, we hypothesized that there was a correlation among food safety culture and *L. monocytogenes* prevalence at retail. We aimed to identify risk factors associated with high *L. monocytogenes* prevalence and deduce feasible recommendations to support sustainable improvement. Specifically, we explored the correlation among infrastructure designs, management strategies, sanitation practices, sense of commitment, and *L. monocytogenes* prevalence in retail deli and produce environments. We also developed a predictive risk model to predict high *L. monocytogenes* prevalence, which, combined with food safety culture survey and deep clean intervention, could be adopted for routine assessment with further validation.

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CHAPTER 2. PREDICTIVE RISK MODELS COMBINED WITH EMPLOYEE- AND MANAGEMENT-IMPLEMENTED SSOPS IDENTIFIED AND REDUCED *LISTERIA MONOCYTOGENES* PREVALENCE IN RETAIL DELIS

2.1 Abstract

Ready-to-eat (RTE) deli meats sliced at retail are predicted to cause 83% of deli meat-associated listeriosis cases annually. While *Listeria monocytogenes* is commonly found in delis, environmental prevalence varies by store (0-40%). A deep clean sanitation standard operating procedure (SSOP) executed by a third-party cleaning service immediately reduced *L. monocytogenes* prevalence in delis, but reductions were not sustained over time. The purpose of this study was to assess the efficacy of a *L. monocytogenes* predictive risk model and a subsequent deep-clean SSOP (deep clean) conducted by store employees and management complemented with training and facilities improvements all aimed to reduce *L. monocytogenes* prevalence in stores with known high *L. monocytogenes* prevalence and evidence of persistence. Fifty delis among six states were screened using a logistic regression model that estimates the probability of high *L. monocytogenes* prevalence in a deli. The model identified 13 stores with potentially high *L. monocytogenes* prevalence; seven stores were confirmed and enrolled for further study. Retail employees executed deep clean; additional interventions (e.g., facilities improvements, training) were incorporated in stores. Environmental samples (n=20 per store) were collected immediately before and after, and monthly for six months post-deep clean. Deep cleans immediately reduced *L. monocytogenes* prevalence in six of seven stores tested. A total of 21/138 (15.2%) samples before and 8/139 (5.8%) samples after deep-cleaning were positive for *L. monocytogenes*, with a marginal 16.0% decrease on non-food-contact surfaces (NFCS) immediately after deep clean ($p=0.0309$, $\alpha_{adj}=0.0125$) and a marginal 10.8% on NFCS during follow-up ($p=0.0337$, $\alpha_{adj}=0.0125$). Employee executed deep cleans with training, education, and maintenance programs can reduce environmental *L. monocytogenes* prevalence in retail delis, a pivotal part of preventing subsequent cross-contamination to RTE deli meats.

2.2 Introduction

In 2003, a joint FDA-USDA-CDC quantitative risk assessment attributed the vast majority of human listeriosis cases to consumption of ready-to-eat (RTE) luncheon meats (USDA & FDA, 2003). One risk assessment concluded that up to 80% of listeriosis-related deaths result from consumption of RTE meats that are cross-contaminated at retail (Pradhan et al., 2010). A follow-up longitudinal environmental monitoring study found *L. monocytogenes* in 29/30 full-service retail delicatessen (deli) departments post-sanitation and pre-operation at least once (Simmons et al., 2014). More specifically, this study found 8/30 delis had high *L. monocytogenes* prevalence (>10%) on environmental surfaces compared to 9/30 with low prevalence (<1%) (Simmons et al., 2014). Further, 12/30 had evidence of persistence (Simmons et al., 2014). In conjunction with other studies (Etter et al., 2017; Hoelzer et al., 2011; Sauders et al., 2009), these data clearly indicate that retail delis have harborage sites capable of harboring *L. monocytogenes* that may contribute to contamination of RTE deli meats and other foods handled at retail by cross-contamination. The importance of cross-contamination from environmental sites for *L. monocytogenes* transmission is well established (e.g., Hoelzer et al., 2012; Pouillot et al., 2015; Pradhan et al., 2011). Taken together, these data indicated a need for strategies to identify delis with high prevalence and increased likelihood of persistent contamination in order that retailers can focus limited resources to mitigate the facilities posing the most risk.

In a recent study by our group, we reported that enhanced daily sanitation standard operating procedures (SSOPs) did not universally reduce *L. monocytogenes* prevalence overall (Etter et al., 2017). However, limited systems to verify execution of enhanced SSOPs daily within all participating delis raised the question of whether SSOPs were ineffective by design, or whether protocols were not performed correctly due to lack of training, supervision, and support. In a follow-up study, we evaluated a modified deep clean SSOP event (referred to hereafter as "DC-SSOP") to control environmental *L. monocytogenes* (Hammons et al., 2017). The intervention was supervised by our research team and executed equally across participating delis by a third-party cleaning service. DC-SSOP immediately reduced *L. monocytogenes* prevalence in two of four delis with high prevalence (>10%) (Hammons et al., 2017). However, reductions were not sustained over time (Hammons et al., 2017), which we partially attribute to limited associate training and follow-up. Third-party deep cleans did not address personnel behaviors and routines that allowed the accumulation of soils and environmental contamination.

The goals of this study were to (i) develop methods to identify retails delis with elevated risk of environmental *L. monocytogenes* contamination, and (ii) evaluate employee-executed deep cleans with targeted follow-up as *L. monocytogenes* control strategies for facilities with prevalent and persistent environmental *L. monocytogenes*. In this study we developed models that identify retail delis that are at an increased risk for prevalent and persistent environmental *L. monocytogenes* contamination to support practical, science-based, and resource-focused approaches to control *L. monocytogenes.* Further, we addressed the limitations of previous *L. monocytogenes* control strategies by (i) providing *Listeria*-specific food safety training to retail employees, (ii) supervising employees during the execution of revised deep cleaning SSOP, and (iii) supporting follow-up actions to address niches within participating stores in the post-deep clean study period.

2.3 Materials and Methods

2.3.1 Identification of stores with increased risk of high *L. monocytogenes* prevalence

We constructed a logistic regression models with forward-stepwise selection and Firth's bias correction, using previously collected data in SAS v9.4 (SAS Institute, Cary NC) (n=30 delis, 28 sites, 6 months, 4503 samples; Simmons et al., 2014) to predict the probability of a retail deli establishment having high *L. monocytogenes* prevalence (defined as >10% *L. monocytogenes* positive samples among those collected in that study). Contamination risk of the entire deli environment was set as a binary response variable, with "0" as low *L. monocytogenes* risk (<10% monthly prevalence) and "1" high risk (>10% monthly prevalence); environmental sites were independent variables that correlate strongly with the overall contamination level. Sites with less than 16 sampling data points were excluded from model construction; this eliminated service case adjacent to raw meat counter, floor-to-wall juncture beneath single-basin sink, cold storage room floor drain, standing water on deli floor, floor squeegee, floor hose, and deli cutting board from the models. Model cut-off values were selected to control type II error ($\beta<0.05$) in the source dataset. As opposed to type I error, which falsely rejects true negative contamination risk and produces a false positive, type II error falsely rejects true positive risk and produces a false negative. Therefore, controlling type II error reduces the risk the model would fail to identify a deli with high prevalence *L. monocytogenes*, exclude the deli from interventions, and allow a high

prevalence environment to remain a risk to public health. Each model was internally validated using 70/30 exclusion, where model effects were estimated from 70% of the data randomly selected. The estimated model coefficients were applied to the remaining 30% of data to determine type I and II error. External validations were performed with an additional six-month sampling period in the same delis (n=4495 samples) (Etter et al., 2017).

Two models were developed for delis with and without floor drain-associated sites (model A and B, respectively; Appendix A). Model A was comprised of five sites: deli floor drain, trash can, scale touch points, cold storage room floor, and cold storage room racks (Table 2.1; Appendix A). Model B sites included deli floor, scale touch points, cold storage room floor, single-basin sink interior, cold storage room racks, and the floor-to-wall juncture under the three-basin sink (Table 2.2; Appendix A). Details of model factors, point effects, and validation outcomes are described in the results section. All statistical analyses were performed in SAS v9.4 (SAS Institute, Cary, NC).

Table 2.1. Odds ratio estimates for sites included in model A (drain associated sites). CSR stands for cold storage room.

		95% Wald Confidence	
Site	**Point Effect**	**Estimate Limits**	
CSR Floor	46.6	10.0	217.3
Trashcan	169.7	3.7	>999.9
Scale	2.2	0.02	218.0
CSR Racks	20.1	1.6	260.9
Deli Drain	240.7	31.8	>999.9

Table 2.2. Odds ratio estimates for sites included in model B (non-drain associated sites). CSR stands for cold storage room.

Site	Point Effect	95% Wald Confidence Estimate Limits	
CSR Floor	35.8	6.8	188.0
1-Basin Sink Interior	32.3	6.9	150.8
Scale	3.2	0.05	227.8
Deli floor	209.0	5.4	>999.9
CSR racks	23.8	1.8	325.0
3-Basin Sink Floor-to-Wall Juncture	18.7	2.4	143.4

2.3.2 Store selection, environmental sampling and identification of delis with high prevalence and evidence for persistent *L. monocytogenes*

In this study, environmental samples were initially collected from 50 retail deli establishments among six states. Delis were selected by corporate sanitarians who were asked to include delis with and without perceived food safety challenges, and facilities of varying size, layout, and community demographics.

Fourteen corporate retail food safety experts were trained to conduct environmental sampling with sterile disposable gloves and sterile sampling sponges. Pre-moistened sampling sponges with 10 ml neutralizing buffer (Hydra-Sponge, 3M, St. Paul, MN) were used to aseptically swab a specified surface area and site on food contact and non-food contact surfaces (FCS, NFCS). Sanitarians were instructed to sample 10 sites: five sites in model A (Table 2.1), plus 5 highly correlated sites (deli case, deli case handle, deli drain, deli floor adjacent to drain, deli floor, cold storage room floor, cold storage room drain, cold storage room racks, trash can, and scale touch points). However, if floor drains were absent, the floor-wall junction under the three-basin sink were sampled in place of the deli drain and floor adjacent to deli drain, to complete model B (Table 2.2). Slicer blade was sampled irrespective of its predictive power. Sponge samples were shipped overnight on ice to Purdue University and kept at 4^{o}C before enrichment and isolation within 18±5 h of collection.

Sampling results were tested against the logistic regression model with preference given to model A; model B was applied only if floor-drains were not present in the deli. Delis identified by the models as potentially high prevalence were subjected to increased environmental monitoring of 20 FCS and NFCS during operational hours, once monthly for three months to confirm evidence

of *L. monocytogenes* persistence (Appendix B). Facilities with *L. monocytogenes* detected on ≥10% of sites (≥2/20) for at least two of three months tested were selected to participate in interventions.

2.3.3 *L. monocytogenes* detection, isolation, and pulsotyping

L. monocytogenes and other *Listeria* spp. were detected using a modified U.S. Food and Drug Association Bacterial Analytical Manual protocol for detection and isolation of *L. monocytogenes* and *Listeria* spp. from food as described by Simmons et al. (2014). If typical *L. monocytogenes* were present on *Listeria monocytogenes* Plating Medium (R&F Laboratory, Downers Grove, IL), up to four random colonies per sample were sub-cultured to pure cultures in Brain Heart Infusion (BHI; Difco, Detroit, MI) broth then stored at -80°C in 15% glycerol. One representative isolate per sample was subtyped by Pulsed Field Electrophoresis (PFGE). PFGE typing was performed using the standardized CDC PulseNet protocol (CDC, 2017) with slight modifications as described by Hammons et al. (2017). PFGE patterns were analyzed and compared using BioNumerics software (Applied Maths v.6.6), using the unweighted pair group-matching algorithm and the Dice correlation coefficient as described previously (Hunter et al., 2005). *L. monocytogenes* was considered persistent if the same PFGE type was detected within two or more sampling events from a single facility (Simmons et al., 2014).

2.3.4 Development and evaluation of interventions in high prevalence stores

We collaborated with corporate sanitarians and food safety managers from each retail chain to optimize potential control strategies in stores identified as having high *L. monocytogenes* prevalence. Control strategies were categorized into three types (i) employee-executed deep cleans, (ii) *L. monocytogenes* education and training, and (iii) follow-up actions including targeted sanitation and adenosine triphosphate (ATP) testing. Control strategies were selected based on feasibility, cost, and likely impact, and then individualized for each store. Employee- and management- executed deep clean SSOPs (referred to hereafter as "deep clean") were conducted in each store. *L. monocytogenes* and listeriosis prevention education and training seminars were offered to employees at various levels in each retail organization. Follow-up actions were conducted in the six to nine months immediately following deep clean execution in each store and were unique to each store.

Immediate pre-deep clean environmental samples were collected after food products were removed and before cleaning began from the same 20 sites used in baseline testing (Appendix B). Immediate post-deep clean samples were collected post-sanitizer application and before restocking food products. Post-intervention samples were collected once monthly six to nine months as described for baseline environmental monitoring. Two deep cleans were executed in deli 37 due to barriers to effective SSOP execution in the first deep-clean (detailed below). As a result, samples immediately before, after, and six months follow-up testing for the second deep clean in deli 37 were used to evaluate deep clean efficacy when performed as designed.

The deep cleaning protocol used in this study was revised from a third-party deep cleaning protocol developed by our group (Etter et al., 2017) (Appendix C). Specific modifications included: (i) training retailer-selected employees to execute the cleaning, (ii) extending cleaning to two, eight-hour shifts of 10-12 associates each during a 12-16 h overnight shutdown period, (iii) dividing labor into four teams (Figure 2.1), (three-compartment sink, cold storage room, front-of-house, and back-of-house), (iv) floors and floor drains were cleaned once mid-way through the protocol to removed debris and heavy soils, then a second time after all other deli surfaces were rinsed but before sanitizer application. The two largest establishments (deli 35 and 64) were cleaned over two consecutive nights of 12 h each as these facilities handled RTE products in a large (>2,200 ft^2) space shared with prepared foods, restaurant kitchens, sushi bars, and/or quick-service sandwich bars. The timeline and order of cleaning is described in Figure 2.2. Retailers implemented follow-up actions during the post-deep clean follow up sampling (Table 2.3). Targeted cleaning was defined as sanitation efforts beyond daily SSOPs conducted to address *L. monocytogenes* detected in monthly post-intervention sampling. Retail establishments were sampled monthly as described above for at least six months post-deep clean to determine long-term efficacy of sanitation improvements. Post-intervention sampling for *L. monocytogenes* was extended in deli 53 to monitor use of ATP verification for daily sanitation (n= 9 months).

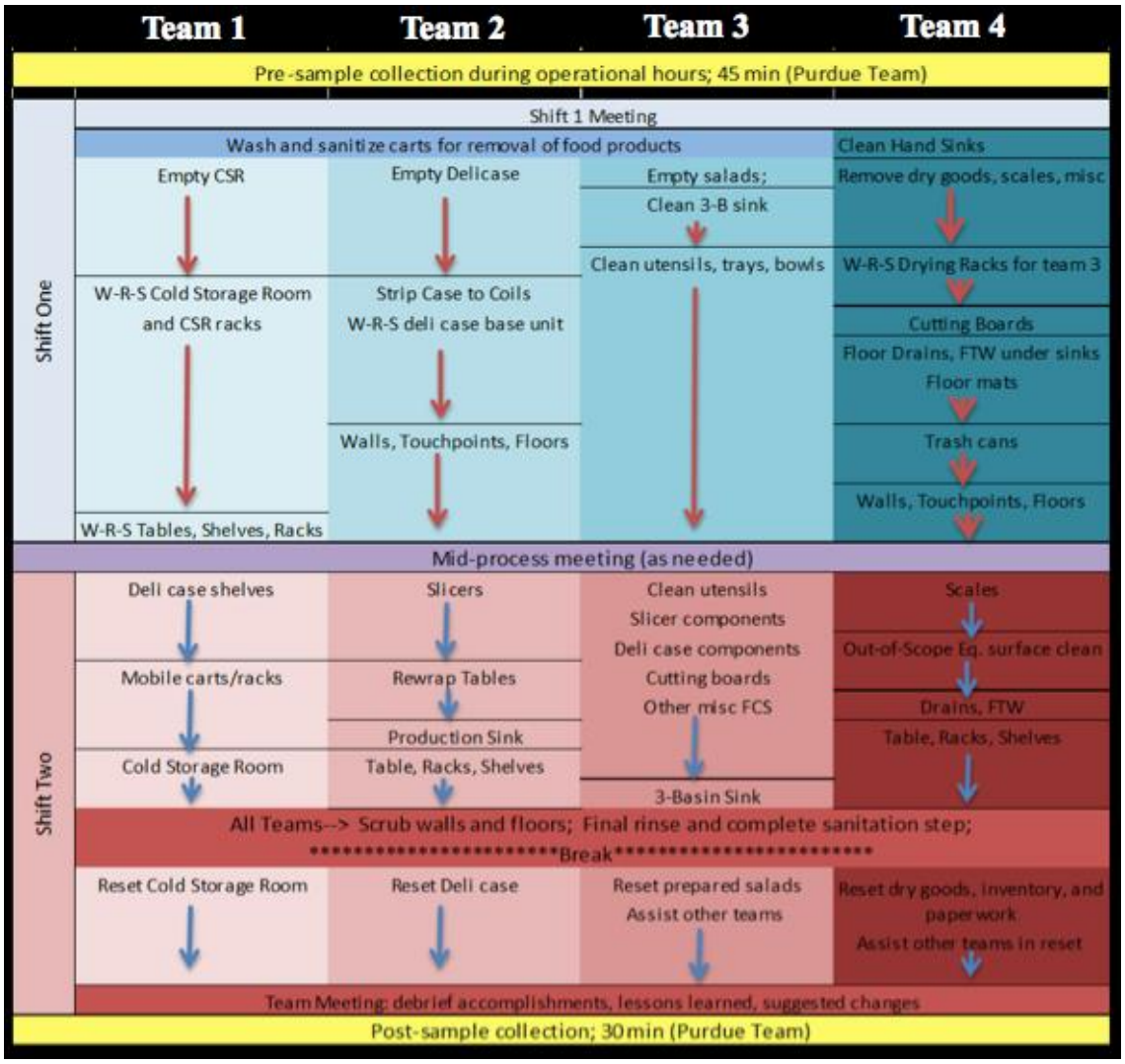

Figure 2.1. Deep clean SSOP division of labor and priorities by deli zone for a 1-day event. Teams are color coded left-to-right to represent cold storage room, front-of-house, three-compartment sink, and back-of-house.

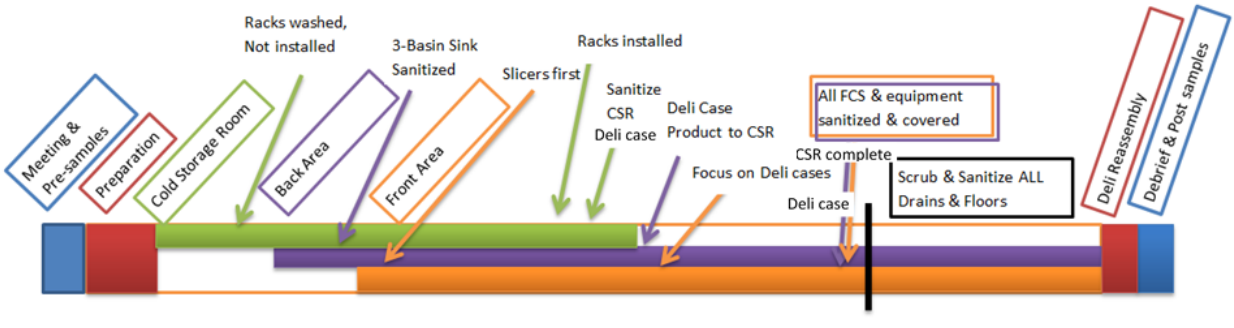

Figure 2.2. Timeline and order of cleaning operations. Time progresses left-to-right with tasks color coded. Note the black line-distinguishes when all FCS and equipment was completed then floors and drains were cleaned and sanitized again.

Table 2.3. Interventions executed in each of seven stores.

Store	Deep Clean				Education/Training				Follow-up Actions					
	Duration		Crew											
	1 night	2 night	Store Managers & Deli Managers	Deli Merchandizers & Associates	Senior Corporate Leadership	Store Managers & Deli Managers	Deli Associates	Deli Merchandizers	Targeted cleaning	Facilities Improvements	2nd Deep Clean (B)	ATP Daily validation	New SSOPs	
35		X	X		X	X			X					X
37	X		X		X	X			X		X	X	X	
39	X		X		X	X			X					X
40	X			X	X	X	X		X	X				
44	X			X				X						
53	X			X				X		X		X		
64		X	X		X	X			X					X

2.3.5 Statistical analyses

Environmental monitoring data were classified into five periods: 1) screening, 2) pre-intervention baseline testing (n= 3 months), 3) immediately before deep clean, 4) immediately after deep clean, and 5) follow-up testing (n ≥ 6 months). Monthly prevalence was assessed for trends resulting from repeated measures in each deli before averages were taken; no trends were observed. A linear mixed model was constructed using the Proc Glimmix procedure and Gaussian distribution in SAS 9.4 (SAS Institute, Cary, NC) to evaluate the immediate and long-term impacts of the deep clean on observed prevalence in each store by surface type (FCS and NFCS), where prevalence = (count *L. monocytogenes* detected) / (number of samples tested). "Group" (low risk, potentially high risk, and subjected to intervention), "period", "surface", and their interactions were designated fixed effects, while "store" (nested within group) and "period*store(group)" were random effects. Bonferroni's adjusted alphas were applied to each two- and three-factor interaction (surface*period, group*period, surface*period*group) least squared means family of comparisons.

2.4 Results and Discussion

In this study, we developed models to identify retails delis with elevated risk of environmental *L. monocytogenes* contamination and evaluated employee-executed one-time sanitation events ("deep cleans") as *L. monocytogenes* control strategies for facilities with >10% prevalence and evidence of persistence. Our data indicate that (i) the models are effective, but conservative, resource-focusing strategies for identifying potentially highly contaminated delis, (ii) employee-executed deep cleans immediately reduced prevalence in six of seven facilities, (iii) interventions marginally reduced average monthly *L. monocytogenes* prevalence on NFCS both immediately and long-term after intervention, and (iv) some, but not all, *L. monocytogenes* strains persisted post-interventions. Below we discuss our findings as well as our limitations, challenges, and future directions.

2.4.1 Developed models conservatively predict stores with high *L. monocytogenes* environmental prevalence

External validation of model A, which includes drain-associated sites (cold storage room floor, trashcan, scale, cold storage room racks, and deli floor drain), successfully predicted high *L. monocytogenes* contamination in 165/179 events (α=0.0615, β= 0.0168) (Table 2.1). Deli floor drain and trash can were the most influential factors in model A. Detection of *L. monocytogenes* on the floor drains increased the probability of high prevalence by 241-fold (CI_{95}=32, >999) compared to delis that tested negative on floor drains. Probability of high prevalence increased 170-fold if *L. monocytogenes* was isolated from trash cans (CI_{95}=3.7, >999) (Table 2.1).

While drain and drain-associated sites (e.g. floor adjacent drain) were the most significant predictors in the model, not all stores have drains. Model B was constructed to evaluate delis without floor drains. External validation of model B (Table 2.2; cold storage room floor, single-basin sink interior, scale, deli floor, floor-wall juncture underneath three-compartment sink, and cold storage room racks) predicted high prevalence *L. monocytogenes* contamination in 159/179 events (α=0.0503, β=0.0615). Deli floor was the most predictive sampling site in model B. Detection of *L. monocytogenes* on the deli floor increased the probability of a store being predicted to have high environmental *L. monocytogenes* contamination by 209-fold (CI_{95}= 5.4, >999).

Collectively the models identified 13 of 50 delis with previously unknown *L. monocytogenes* contamination history to have increased risk for high *L. monocytogenes* prevalence

(Appendices A & C). Seven delis were confirmed to be highly prevalent with evidence of persistence after three months of longitudinal environmental testing (≥2 of 20 food and non-food contact surfaces *L. monocytogenes* positive ≥2 months) and were selected for intervention implementation and follow-up testing. The screening models are conservative and potentially useful for retailer resource focusing efforts, but are not intended for use in regulatory enforcement due to the considerable false-positive identification rate (6/13 delis).

Food Safety Modernization Act (FSMA) and Codex guidelines specified that the emphasis of *L. monocytogenes* control should shift from hazard-based to preventative risk-based and encourages the development of predictive models to curb foodborne pathogen outbreak (Codex Alimentarius, 2007; FSMA, 2018; World Health Organization & Food and Agriculture Organization, 2006). Food Safety and Inspection Service (FSIS) detailed three components in food safety risk analysis, including risk assessment, risk management, and risk communication to reduce the likelihood of exposing public health to foodborne harms and hazards (FSIS, 2013). Under this approach, software and statistic models have been used to manage and evaluate the growth and inhibition of foodborne pathogens chiefly in food matrixes (Jarvis, 2016; Ross, McMeekin, & Baranyi, 2014; Tenenhaus-Aziza & Ellouze, 2015) such as *Vibrio parahaemolyticus* in oyster species (Parveen et al., 2013). Risk assessments at retail deli have been performed to identify factors leading to greater hazard. Gibson et al. (2013) elucidated (via fluorescent compound surrogate) that deli meat wrapper, meat grip, slicer knob, etc. were high hand contact sites during a standardized meat-slicing task at a mock retail deli environment. The frequency of hand-contact was positively correlated with cross-contamination level, indicating high-risk status (Gibson et al., 2013). In a recent FSIS risk assessment on *L. monocytogenes* contamination in retail deli, a "virtual deli" model was developed using existing databases to illustrate the various site-interaction dynamics resulting in potential cross-contamination (FSIS, 2013). The report concluded that incoming *L. monocytogenes* sources significantly contaminated in-deli environments and other RTE products. Moreover, cleaning the environment without sanitizing also posed a greater risk to *L. monocytogenes* levels (FSIS, 2013). However, despite initial efforts investigating risk factors and preventative measures to control *L. monocytogenes* at retail, proper food handling, personal hygiene and sanitation still poses as a major challenge to food safety.

Potential for cross-contamination from the environment to foods is well established at retail (Gaulin, Ramsay, & Bekal, 2012; Hoelzer et al., 2012; Simmons et al., 2014) and in food

processing environments (Ferreira et al., 2014; Ho, Lappi, & Wiedmann, 2007; Jami et al., 2014; Leong, Alvarez-Ordóñez, & Jordan, 2014; Muhterem-Uyar et al., 2015). Previous studies have identified great value and urgent need for elucidating and assessing environmental factors impacting food safety (Gallagher et al., 2016; Hoelzer, Pouillot, & Dennis, 2012). Maintaining an adequate, hygienic food safety environment is crucial for ensuring food safety. Predictive models can be useful tools to help retailers identify stores that warrant more significant investments to mitigate increased likelihood of high *L. monocytogenes* prevalence, thus reducing public health risks.

2.4.2 Deep cleans immediately reduce *L. monocytogenes* prevalence in six of seven stores tested

A deep clean intervention protocol was executed in all stores with timeline modifications to accommodate larger facilities cleaned over two consecutive nights (Figure 2.2, Appendix C). Sanitation personnel, food safety education and training, and follow-up actions varied by retail establishment (Table 2.3). *L. monocytogenes* prevalence and persistence in each deli are detailed in Appendix E. Deep cleans immediately reduced *L. monocytogenes* prevalence in six of seven stores (Table 2.4). Although deep clean execution in delis did not significantly reduce *L. monocytogenes* prevalence in the aggregate, prevalence was reduced from 21/138 (15.2%) before deep clean to 8/139 (5.8%) positive for *L. monocytogenes* immediately after deep-cleaning among all seven stores.

Table 2.4. Samples positive for *L monocytogenes* immediately before and after deep cleaning in deli establishments with evidence of high prevalence and persistent environmental *L. monocytogenes*. Data after the second deep clean in store 37 are included.

Store	%LM Before	%LM After
35	10 (2/20)	20 (4/20)
37	21.1 (4/19)	5.3 (1/19)
39	35 (7/20)	5 (1/20)
40	10.5 (2/19)	0 (0/20)
44	15 (3/20)	10 (2/20)
53	5 (1/20)	0 (0/20)
64	10 (2/20)	0 (0/20)

Extreme facilities challenges hindered execution of the deep clean protocol as designed on the first attempt in deli 37. Specifically, the deli floors were flooded due to clogged drains that required an emergency plumbing service for remediation despite guidance to ensure free flowing drains prior to deep clean SSOP execution. Not surprisingly, *L. monocytogenes* prevalence increased from 16.7% (3/18) immediately pre-deep clean to 21.1% (4/19) immediately post-deep clean (Figure 2.3). Deli 37 retained high *L. monocytogenes* prevalence for five months after the initial deep clean attempt with overall prevalence 18.8% (19/101) (Figure 2.3). A second deep clean intervention executed five months later immediately reduced *L. monocytogenes* prevalence 15.8 percentage points (before 21.1% (4/19) to after 5.3% (1/19)). Environmental monitoring data from the second event were used to evaluate efficacy of the deep clean when executed as designed.

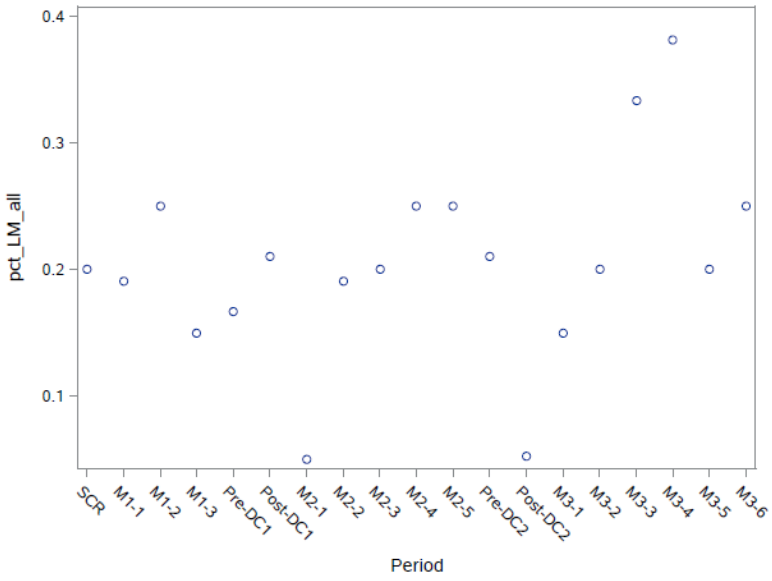

Figure 2.3. *L. monocytogenes* prevalence in deli 37 over the study period from the initial Screening Phase to post-second-intervention follow-up. Y axis represents *L. monocytogenes* prevalence in percentage; x axis represents the study periods, with "SCR" initial Screening Phase, "M1-#" each visit during Baseline Monitoring Phase, "pre-DC#" immediately before deep clean, "post-DC#" immediately after deep cleaning, "M2-#" each visit during first deep cleaning follow-up, and "M3-#" each visit during second deep clean follow-up.

Deli 39 was similar to deli 37 in diversity of products handled (RTE, raw chicken and seafood), facility size (i.e. small), and maintenance challenges (e.g. slow floor drains and floors poorly sloped), the deep clean was able to reduce *L. monocytogenes* prevalence from 35% (7/20)

L. monocytogenes positive samples before intervention to 5% (1/20) *L. monocytogenes* positive immediately post-intervention. Deep cleans in deli 39 took place after deli 37 and our team was alerted to potential challenges related to floors and service case design. Heightened awareness and resulting protocol changes (such as pre-clearing floor drains) likely contributed to the reduced prevalence of *L. monocytogenes* in deli 39 compared to deli 37 immediately post-deep clean.

Studies have demonstrated that food safety behavior is organization- and behavior-based, rooted in commitment, risk awareness, effective management and communication (Arendt et al., 2014; Griffin, Livesey, & Clayton, 2010). Motivating behavior change not only benefits from modern technology and scientific knowledge, but strong communication and management skills (Powell, Jacob, & Chapman, 2011). Powell et al. (2013) argued further that food safety behavior and perception were more pivotal than standard inspections and audits to minimize food safety risk, which illustrates the need to direct resources to improve employees' awareness and training. Personal hygiene education and proper management were prioritized as the intervention treatment to improve food safety in small vendors in Madagascar that had found fecal contamination (Sarter & Sarter, 2012). Our results confirmed the importance of raising awareness through management-supported initiatives to construct functional food safety programs at retail.

Facilities maintenance challenges were often the largest inhibitors of deep cleaning protocol execution and success. Infrastructure cleanability was identified as a significant factor impacting *L. monocytogenes* prevalence at retail produce environments, with compromised cleanability correlated with greater *L. monocytogenes* contamination (Wu et al., accepted). Worn grout or broken tiles on floors allowed accumulation of water and soils (FDA, 2017; FSIS, 2014; FSIS, 2015). Studies have shown that epoxy flooring was more prone to blistering (Ignoul, van Rickstal, & van Gemert, 2004) and cracking (Causin, Marega, & Marigo, 2007), which can pose severe sanitation challenges. Additionally, infrastructure design prone to forming standing/pooled water and inaccessible for cleaning are indicators of high *L. monocytogenes* contamination risk (Etter et al., 2017; FSIS, 2014; FSIS, 2015; Simmons et al., 2014). Therefore, limited access to drains (e.g. placement beneath cabinets) and improperly sloped floors near drains often inhibited practical use or ability to clean.

Deli 35 was the only deli in which *L. monocytogenes* increased after completion of the deep clean. *L. monocytogenes* increased from 10% (2/20) pre-intervention to 20% (4/20) post-intervention. Several factors contributed to the complexity of this environment including, but not

limited to, a third party vendor restaurant with the same area facilities maintenance challenges. One specific challenge was gaps between deli service cases and flooring, allowing accumulation of food debris underneath the cases behind a metal kick plate attached with multiple screws. This harborage area was discovered and addressed after the deli floors had been cleaned. Although this space was addressed, the late discovery meant that water used to clean food debris from below the service case flowed over the previously cleaned floors. This may have allowed organisms previously in the area beneath the deli case to spread through the environment. In the first month post-deep clean, deli 35 conducted targeted cleaning of floor surfaces, including the area beneath service cases, to address the post-deep clean increase in *L. monocytogenes* prevalence before the first follow-up testing event.

Although deep clean interventions have been previously studied, their efficacy and best approach remain complex. Deep cleans were conducted in delis with low, moderate, and high *L. monocytogenes* prevalence, in which mixed results were found both immediately after deep clean and during longitudinal follow-up (Etter et al., 2017). Overall, the deep clean did not reduce *L. monocytogenes* prevalence and persistent strains in the retail deli environments, but successes occurred with targeted follow-up (Etter et al., 2017; Hammons et al., 2017). Similarly, mixed results were found in a more recent deep clean intervention conducted in retail produce environments, as some *L. monocytogenes* persisted through the intervention period (Burnett et al., in prep). Given the prominent role of food safety behaviors and perceptions in constructing a safe foodservice environment (Arendt et al., 2014; Griffin, Livesey, & Clayton, 2010), it is difficult to verify if SSOPs were effectively followed and executed, and there was no mechanism to track and verify food safety behaviors of the employees. Consistent with previous findings, our intervention in delis with high *L. monocytogenes* contamination risk yielded mixed results, which underscores that additional factors and interventions are necessary to control *L. monocytogenes* in retail.

2.4.3 *L. monocytogenes* prevalence on non-food contact surfaces reduced 16% immediately and 10.8% long-term post-deep clean

In a linear mixed model, we observed significant differences in means of fixed effects "group", "period", "surface", "group*period", "surface*group", and "surface*group*period" across *L. monocytogenes* prevalence in a store ($p<0.05$; Type III tests of fixed effects), model conditions illustrated in Figure 2.4. *L. monocytogenes* prevalence on NFCS was significantly

higher than on FCS among the six high risk delis during the screening phase (p=0.0014) and among the seven high prevalence delis throughout the study period except immediately after deep clean (p<0.0001). While the immediate and long-term efficacy of deep clean was overall not statistically significant, *L. monocytogenes* prevalence on NFCS was reduced by 16.0% immediately after the intervention (p=0.0309, α_{adj}=0.0125); prevalence on NFCS was marginally reduced by 10.8% during follow-up (p=0.0337, α_{adj}=0.0125). There were no detectable impacts on FCS immediately or long-term after deep clean and sanitation interventions.

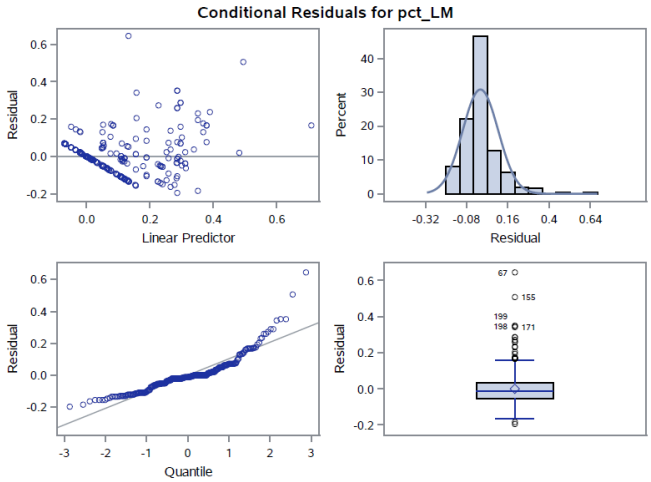

Figure 2.4. Statistical diagnostic for the linear mixed model.

NFCS have been reported as the major harborage area of *L. monocytogenes* at retail, having significantly higher prevalence than FCS in both deli (Hoelzer et al., 2011; Sauders et al., 2009; Simmons et al., 2014), RTE foods (Kovacevic et al., 2012), and produce environments (Burnett et al., in prep). Although NFCS testing for *L. monocytogenes* is recommended in preventing cross-contamination and controlling *L. monocytogenes* risk (FDA, 2017; FSIS, 2012; FSIS, 2014) it is not required. *L. monocytogenes* can easily persist on NFCS, such as floors (Campdepadrós et al., 2012; Salo et al., 2006), that are not cleanable. In a recent retail deli study, NFCS were persistent harborage sites of *L. monocytogenes* (Etter et al., 2017). Cleaning and sanitation challenges result in organic soils accumulation and biofilms formation (Blackman & Frank, 1996; Shi & Zhu, 2009). Once biofilms are formed, sanitation and deep clean efficacy can be limited (Belessi et al., 2011; Fernandez, Kabuki, & Kuaye, 2015; Pan, Breidt, & Kathariou, 2006). Additional extrinsic factors impacting disinfection efficacy, as reviewed by Hoelzer et al. (2012), include lower concentrations

due to soils, presence of protein residues, too short or too long the contact time, ambient temperature, surface structure, etc.

2.4.4 PFGE confirmed some *L. monocytogenes* strains persisted through deep clean interventions

Pulsotype data on isolates collected within each high prevalence establishment over the course of the study are included in Table 2.5 and Appendix E. Post intervention isolates from deli 53 were typed 6 of the total 9 months sampled during follow-up. Among the total 243 isolates, 87 distinct pulsotypes were identified; two isolates were untypable with *Asc*I. Six pulsotypes, four of which were transient, were found in more than one deli, typically in the same state. All seven delis exhibited distinct *L. monocytogenes* pulsotype cohorts. Overall, seven pulsotypes were persistent among four delis. Five delis had a pulsotype detected both before and after deep cleans; at least one pulsotype persisted for the duration of the study in two delis.

Table 2.5. PFGE pulsotypes of isolates before and after deep cleans in delis with high prevalence.

Pulsotypes of isolates were compared within the study and expressed as SS-*Asc*I#-*Apa*I#.

Site[A]	Period	Deli 35	Deli 37	Deli 39	Deli 40	Deli 44	Deli 53	Deli 64
Cold room racks	Before[B]			SS-80-60				
	After[C]		SS-40-61				SS-20-120	
3-Basin sink interior	Before							
	After	SS-81-22						SS-120-14
1-basin interior	Before		SS-71-41			SS-40-10		
	After							
Cutting board	Before						SS-12-120	
	After						SS-20-150	
Re-wrap table	Before		SS-80-60					
	After							
Counter top	Before	SS-80-62						
	After							
Deli drain	Before		SS-70-20[D] SS-71-21 SS-40-20	SS-40-20 SS-80-60	SS-90-10 SS-90-10	SS-220-170	SS-10-140 SS-10-112 SS-10-120	
	After		SS-80-20 SS-40-41 SS-40-20 SS-40-20 SS-40-40 SS-40-20	SS-40-90	SS-41-12		SS-20-120 SS-10-120 SS-20-120 SS-10-132 SS-80-10 SS-10-120	
Deli area floor adjacent to drain	Before		SS-70-20	SS-80-31 SS-31-60	SS-90-10		SS-10-141 SS-10-120	
	After		SS-40-40 SS-40-10 SS-40-20 SS-40-40 SS-40-20	SS-80-60 SS-80-70 SS-31-60	SS-200-104	SS-223-173	SS-20-120 SS-21-130 SS-10-110 SS-10-120	

Table 2.5 continued

Deli floor	Before	SS-40-50		SS-80-70 SS-80-70			SS-160-100 SS-10-12 SS-10-120	
	After	SS-40-40 SS-40-20					SS-10-120 SS-10-151 SS-10-131 SS-20-120	SS-92-20
Cold room floor	Before	SS-120-14			SS-90-11 SS-90-10 SS-60-10	SS-220-170	SS-20-140 SS-21-120 SS-10-120	SS-60-10
	After		SS-40-20	SS-80-70			SS-10-120 SS-21-120 SS-20-150 SS-10-110 SS-20-120	
Cold room drain	Before	SS-190-20	SS-190-40	SS-80-70 SS-80-60 SS-80-70			SS-20-120	SS-150-30 SS-140-52 SS-92-71
	After		SS-40-40 SS-40-20 SS-210-103	SS-80-21 SS-30-40 SS-30-40 SS-30-40			SS-10-150 SS-10-150	SS-90-52
Trash can	Before				SS-90-10			
	After		SS-40-20	SS-30-72				
Standing water	Before		SS-70-20	SS-80-70	SS-70-10		SS-20-140 SS-20-120	
	After		SS-40-40 SS-40-40				SS-10-132 SS-10-152 SS-10-150 SS-10-112 SS-22-80	SS-61-10 SS-na-101
Squeegee	Before	SS-60-10 SS-81-22	SS-40-51 SS-40-20	SS-80-60 SS-80-70 SS-80-60		SS-220-170 SS-220-170	SS-180-160 SS-10-120 SS-11-120	SS-60-10 SS-40-10
	After		SS-40-20 SS-40-20 SS-40-41 SS-40-20 SS-40-20	SS-80-32 SS-30-40 SS-31-72		SS-220-170	SS-10-120 SS-10-111 SS-10-120 SS-10-120	SS-92-10 SS-130-14 SS-92-52 SS-62-20
3-Basin floor-to-wall juncture	Before	SS-80-62	SS-70-20 SS-40-20	SS-80-71 SS-80-60				SS-60-10 SS-42-10 SS-61-52
	After		SS-40-20 SS-40-20 SS-40-20 SS-40-20 SS-70-20 SS-40-20					SS-120-14

[A]Slicer, slicer knob, scale, deli case handle, and deli case tray sites were sampled but no *L. monocytogenes* was recovered;
[B]Rows labeled "Before" represent isolates recovered during the two month screening period before the deep clean;
[C]Rows labeled "After" represent isolates recovered during the six months longitudinally sampled post-deep clean;
[D]Repeated pulsotypes in a cell indicate that the same pulsotype was recovered from more than one sampling event (month).

As an example, pulsotyping identified one persistent strain (SS-220-170) in deli 44; this pulsotype was detected on several NFCS on four of the five sampling events before the deep clean

intervention (Table 2.5, Appendix E). This pulsotype was also detected immediately after deep clean on floor and drain in the deli area. However, this pulsotype was not detected except the last month of the six-month follow-up, supporting that the execution of the deep clean protocol, employee education and training, and targeted cleaning follow-up, could temporarily eliminate strain SS-220-170 from the deli establishment. Additionally, one other transient strain was detected in deli 44 during the post-deep clean sampling period, emphasizing the need for effective daily sanitation procedures.

Several persistent strains of *L. monocytogenes* were detected in deli 39 (Table 2.5, Appendix E). Pulsotypes SS-80-60 and SS-80-70 were detected in four and three months, respectively, among the five-month pre-intervention sampling. SS-80-60 was only detected once post-intervention, and SS-80-70 twice. SS-30-40 was detected four months post-intervention and persisted for three months; this pulsotype was also found immediately before deep clean as a result of a major contamination event, accounting for 4/7 *L. monocytogenes* samples detected. With the extended period between detections, it is possible, but not highly probable, that these strains were effectively removed from the deli area by the intervention protocols and then reintroduced from outside the deli by contaminated food products or transmitted by employees from environmental sources. In store 37, where severe infrastructure obstacles obstructed the intervention efforts and deep clean was executed twice. SS-40-40, a strain not detected until the last month before the second intervention, persisted thereafter (Appendix E). Due to cost, our study limited PFGE typing to one isolate collected from each *L. monocytogenes* positive sample site. The matching, *Apa*I patterns suggest a need to further investigate the relatedness of these strains by another technique (e.g. whole genome sequencing) Our previous longitudinal studies reported similar events where delis with previously low (<1%) prevalence, had high (>10%) prevalence *L. monocytogenes* during a sampling event with all isolates sharing a pulsotype (Etter et al., 2017; Simmons et al. 2014).

Given *L. monocytogenes* is ubiquitous in the natural environment, it is implausible to eradicate this pathogen (Buchanan et al., 2017); controlling it is the objective. Although its persistence has been observed and studied in multiple environments including meat/seafood plants (Ferreira et al., 2014; Leong, Alvarez-Ordóñez, & Jordan, 2014; Ortiz et al., 2016; Vongkamjan et al., 2013), dairy processing/manufacturing facilities (Almeida et al., 2013; Ho, Lappi, & Wiedmann, 2007), at retail (Hoelzer et al., 2011; Simmons et al., 2014; Wang et al., 2015), etc. specific persistence mechanisms remain unclear. Recent studies suggested that genome-

independent factors, such as harborage sites where disinfection was difficult to penetrate (Carpentier & Cerf, 2011), might allow this pathogen to flourish (Carpentier & Cerf, 2011; Stasiewicz et al., 2015). However, more evidence suggests underlying genetic factors impact *L. monocytogenes* persistence. Holch et al. (2013) proposed that molecular adaptation, such as gene deletions, can potentially enhance the survival and promote persistence of *L. monocytogenes*. Additional studies identified and characterized quaternary-ammonium-compounds (QAC)-tolerance genes, *qacH* and *bcrABC*, as a determinant enhancing the survivability and persistence through disinfection (Dutta, Elhanafi, & Kathariou, 2013; Müller et al., 2014). In a Norwegian study, nine meat- and salmon-processing plants environmental were sampled for *L. monocytogenes*; *L. monocytogenes* containing QAC-tolerance genes were highly prevalent (Møretrø et al., 2017). This suggests the possibility that QAC residuals after disinfection may enhance persistence and long-term residency of QAC-tolerate *L. monocytogenes*, but significant work remains. Biofilm formation is another factor potentially impacting *L. monocytogenes* persistence (Reis-Teixeira, Alves, & de Martinis, 2017) as they may protect *L. monocytogenes* cells from antimicrobial action, even positively enhance survival during bactericidal treatment (Belessi et al., 2011; Kocot & Olszewska, 2017; Olszewska, Zhao, & Doyle, 2016; Poimenidou et al., 2016). Genetic factors, such as *sigB*, have been reported to impact biofilm formation ability in *L. monocytogenes* (van der Veen & Abee, 2010). A recent study by Wang et al. (2015) concluded that *inlA* premature stop codons were rare among *L. monocytogenes* isolates from retail but when present were found in transient *L. monocytogenes* strains, rendering the persistent strains more likely to be virulent. The persistent strains were also found to have enhanced adherence and biofilm-forming ability (Wang et al., 2015). While sanitizer tolerance was not significantly different between the transient and the persistent strains, persistence property of *L. monocytogenes* was ascribed to the enhanced adherence and biofilm forming capacity (Wang et al., 2015).

In multiple stores, we observed persistent strains throughout the study and/or same pulsotype detected both before and after intervention. Besides the reintroduction of *L. monocytogenes* from external sources, which was implicated as one of the most salient considerations of *L. monocytogenes* contamination in-deli (FSIS, 2013), persistent obstacles in management and communication challenge deep clean efforts. Optimistic bias, prevalent among food handlers regardless their level of food safety knowledge, can potentially compromise food

safety by omitting necessary procedures (da Cunha et al., 2015; de Sousa Carvalho Rossi et al., 2017).

In general, deep clean did not significantly reduce *L. monocytogenes* prevalence on the sampled delis.

2.5 Conclusions

In this study, we developed conservative screening models as a potential tool for retailers to identify delis with increased risk of high *L. monocytogenes* prevalence. As *L. monocytogenes* is not found at high levels in all delis, identifying delis with high prevalence will help focus resources (e.g., labor hours, facilities upgrades) on environments that may present a larger public health risk. We do not recommend using this screening tool for regulatory enforcement actions, as the models are conservative by design. Scale was the weakest factor among all sites included in both model A and B, rendering caution using this site for *L. monocytogenes* risk prediction. Screening sampling plan in deli environments can be improved by sampling the 1-basin sink interior instead of the slicer blade, to increase its predictive power. While preventing *L. monocytogenes* contamination in retail deli environments is a complex challenge, employee-executed deep-cleans with training, education, and maintenance programs can reduce environmental *L. monocytogenes* prevalence in deli environments. However, single deep-cleaning events were not equally effective in all stores due in part, but not limited to, (i) complexity of the facility design in combination with allocated time, (ii) surfaces that could not effectively be cleaned (e.g., broken tile, deteriorated coving), and (iii) significant soil residue that functions as or supports the growth of biofilms.

This study and others by our group have shown that *L. monocytogenes* is widely spread throughout the deli environment, especially on non-food contact surfaces (Etter et al., 2017; Hammons et al., 2017; Sauders et al., 2009; Simmons et al., 2014). *L. monocytogenes* control strategies should aim to minimizing cross-contamination by (i) zoning product handling in the deli area (e.g., through separating raw meat and RTE meat products), (ii) improving equipment design and deli construction, (iii) improving sanitation practices (e.g., through implementing standard sanitation protocols and through supervision of deli employees by deli managers), and (iv) better personnel management (e.g., through controlling traffic in the deli area). Taken together, this study underscores that improved sanitation strategies combined with facilities maintenance and

improving food safety culture are pivotal in preventing *L. monocytogenes* contamination in retail delis and its cross-contamination to RTE deli meats.

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CHAPTER 3. RETAIL DELI MANAGERS AND ASSOCIATES HAVE BETTER FOOD SAFETY CULTURE IN STORES WITH LOWER *LISTERIA MONOCYTOGENES* CONTAMINATION

3.1 Abstract

Food safety climate and culture is an integral part of a healthy food safety system. While much research has been done on elements of food safety climate and culture, no data are available on their relationship with *Listeria monocytogenes* contamination at retail. We implemented a forty-four-question survey on sense of commitment, employee training, and personal hygiene in 50 United States grocery retail deli departments across six states to evaluate the links among food safety climate, culture, and *L. monocytogenes* control. One deli manager and up to five deli associates per establishment completed the survey. Survey responses were correlated with *L. monocytogenes* contamination risk and prevalence, respectively, via a generalized linear mixed model. Estimate and orthogonal contrast statements with Bonferroni adjustment were applied to elucidate significant effects trends. We found that a greater sense of commitment was correlated with lower *L. monocytogenes* contamination risk (p_{adj}=0.0317). Delis with low risk of contamination reported a better, more complete employee training program (p_{adj}=0.0117). A deep clean intervention significantly improved managers' (p_{adj}=0.0243) and associates' (p_{adj}=0.0057) commitment to food safety and their perceptions of training programs (p_{adj}=0.0291). Significant differences in occupation-disaggregated survey responses were reported regarding sense of commitment, training program, and infrastructure cleanability. Personal hygiene and handwashing had mixed results. This is the first study to elucidate the relationship between food safety climate and *L. monocytogenes* contamination in retail deli environments and provides directionality to sustainably improve food safety climate, culture, and sanitation in retail deli environments.

3.2 Introduction

Listeria monocytogenes is among the leading causes of foodborne illness related death in the U.S., responsible for 1600 cases annually with a 16% mortality rate (CDC, 2019; Scallan et al., 2011). Approximately 99% of listeriosis cases are due to consuming contaminated food (Scallan et al., 2011). Retail environments are identified as high-risk settings prone to *L. monocytogenes*

contamination and cross-contamination (FDA/FSIS, 2013; Hoelzer et al., 2011; Simmons et al., 2014). Deli meat sliced and processed in retail environment is five times more likely to be associated with listeriosis-related death than product sliced and packaged at manufacturing (Endrikat et al., 2010). A previous study found significant variation in *L. monocytogenes* prevalence among 30 retail deli establishments with up to 34.6% samples positive for *L. monocytogenes* and an average of 14.2% positive prevalence on non-food-contact surfaces (Simmons et al., 2014). In a recent retail deli deep clean intervention study, seven delis were identified as highly prevalent, with *L. monocytogenes* prevalence ranging from 5% to 35% immediately before deep cleaning (Wu et al., accepted).

The efficacy of deep cleans in retail delis has had mixed results in mitigating *L. monocytogenes*. Previous studies have shown that deep clean did not significantly reduce *L. monocytogenes* prevalence and persistence in retail delis (Etter et al., 2017; Hammons et al., 2017; Wu et al., accepted). The implementation of a more aggressive third-party deep clean protocol did reduce *L. monocytogenes* prevalence overall, however, it did not uniformly reduce persistent strains over time (Hammons et al., 2017). Similarly, another study, featuring deep cleaning executed by retail establishments' own employees, showed an immediate reduction in *L. monocytogenes* prevalence in six of seven high-risk delis post-deep clean, though, multiple strains continued to persist throughout the study period in some stores (Wu et al., accepted) suggesting gaps in communication of the food safety program, lack of validation, and need for tracking SSOP (sanitation standard operating procedure) execution.

Human factors, such as perceptions and behaviors, are critical to food safety. The concepts of "food safety culture" and "food safety climate" have been distinguished by De Boeck et al. (2015), who proposed food safety culture as "an overarching, sense-making context for the creation and maintenance of food safety perceptions, attitudes, and beliefs across factors of a more temporal character" (De Boeck et al., 2015; Zohar, 2011). Further, food safety climate is defined as an organizational climate of "employees' perception of the situation within an organization" (De Boeck et al., 2015; Neal et al., 2000). To characterize, evaluate, and improve food safety climate and culture, multiple models have been proposed and tested in food processing environments (Ball, Wilcock, and Aung, 2009; De Boeck et al., 2015; Jespersen et al., 2016; Wright and Leach, 2013), emphasizing five global themes, including "Value and Mission", "People Systems", "Risk Management", "Adaptability", and "Consistency" (Jespersen, Griffiths

and Wallace, 2017). A behavior-based maturity model describing progressive evolution from "doubt" to "internalization" was characterized and tested by Jesperson et al. in food processing facilities as a system to measure food safety culture (2016). Certain behavior-based techniques to improve food safety culture in an industrial setting are also suggested and reviewed by Yiannis (2015), underscoring that food safety culture is actually a behavioral science and an organizational effort. Despite many proposed systems to measure and improve food safety climate and culture, their status is further challenged by data collection and analyses (De Boeck et al., 2019; Jespersen and Wallace, 2017), presenting challenges in assessing true perception, behavior, and condition, as well as potential for incorporating bias in identifying whether the data reliably reflected the reality of food safety practices.

Due to limited efficacy of deep clean strategies in retail delis and lack of food safety behavior studies, it is crucial to identify employees' perception and behavior changes – ultimately food safety climate and culture – pre- and post-deep clean in relationship to *L. monocytogenes* contamination risk and prevalence. In this study, we developed a survey to elucidate risk factors in *L. monocytogenes* control and understand the efficacy of deep cleans in improving food safety culture. We hypothesized that i) lower *L. monocytogenes* contamination risk and prevalence is correlated with better perception of food safety culture and ii) a deep clean can improve food safety culture in retail delis. We were also interested in characterizing the dynamics between deli associates and managers from the same establishment in their food safety perceptions and behaviors.

3.3 Materials and Methods

3.3.1 Food safety behavior survey

We modified a food safety culture survey developed by Neal et al. (2012) to a self-reported measurement for retail deli employees. The Institutional Review Board at Purdue University approved the survey before its distribution (IRB Protocol #1212013074). The survey was composed of 44 Likert scale questions pertaining to employees' and management's commitment to a food safety program, employee training, handwashing and hygiene, infrastructure, etc. (Appendix G). There were two parts to the questionnaire: the first asked about level of agreement, the second asked about frequency of the stated observations on scales of 1 to 5. Additional

demographic questions were included at the end of the questionnaire. Based on the definitions of "food safety culture" and "food safety climate" (De Boeck et al., 2015), our modified survey specifically measured food safety culture in each retail establishment, with questions related to individual employee and manager perceptions on both the food safety programs, the work environment, and themselves.

3.3.2 Survey participants and data collection

A 44-question survey of food safety culture was distributed to retail deli managers and associates from 50 retail delis among six U.S. states who previously participated in a longitudinal *L. monocytogenes* prevalence study (Wu et al., accepted). At least one deli manager and up to five deli associates were surveyed from each store. Based on a recently developed *L. monocytogenes* predicted risk model (Wu et al., accepted), seven "high risk" stores were further selected for a deep clean intervention (referred to hereafter as "deep clean"). The survey was distributed via the U.S. Postal Service three times over 12 months. Distribution occurred before and after deep cleaning, as well as during the six-month follow-up period. Each hard copy survey was fastened to a research information sheet and a plain business envelope. English and Spanish versions of surveys and research information sheets were provided to stores known to have bilingual employees. Six sets were included in each manila envelope for each store, along with a pre-addressed and stamped return manila envelope. The manila envelopes were sent to our corporate food safety contacts who were not supervisors nor directly responsible for deli personnel to distribute the surveys. Each participant sealed the completed survey in provided envelope before placing it in the collective return manila envelope, which was mailed back to Purdue University. All survey responses were entered into Qualtrics (Qualtrics, Provo, UT) for subsequent analyses.

3.3.3 Statistical analyses

Statistical analyses were performed in SAS 9.4 (SAS Institute, Cary, NC). Negatively phrased questions were first reverse scored by coding 1 as 5, 2 as 4, 4 as 2, 5 as 1, etc. Principal component analysis was conducted using each store median summary, followed by Promax rotation (Neal et al., 2012) to reduce variables to fewer principal components and achieve the simplest structure. A generalized linear mixed model was developed using Proc Glimmix to

evaluate statistical relationship among *L. monocytogenes* predicted risk with food safety culture. Three main effects were studied: "period" accounting for the three rounds of survey distribution, "occupation" differentiating between positions of management and employees, and "LM risk" capturing high or low risk based on the predicted risk model developed by Wu et al. (accepted). Each of the 44 questions were correlated independently with "period", "occupation", "LM risk", and their two-level interactions (α=0.05). Estimate and orthogonal contrast statements were subsequently included to elucidate the trend and nature of the significant effects. A Bonferroni adjustment was applied to each contrast to control overall significance, with α_{adj} = 0.025 for "period", α_{adj}=0.0083 for "period*LM risk", α_{adj}=0.0071 for "period*occupation", and α_{adj}=0.0125 for "LM risk*occupation". "LM risk" and "occupation" were not adjusted for multiple comparison because they are binary. Analyses were run with both original dataset at individual level (n=498) and median dataset at store level (n=168). A separate generalized linear mixed model was developed with Proc Glimmix to determine the relationship between *L. monocytogenes* prevalence in percentage and the self-reported food safety behavior (n=99).

3.4 Results and Discussion

In this study, we surveyed food safety culture, including sense of commitment, perceived work environment, perceived personal behaviors, and self-awareness on hygiene among retail deli management and employment to elucidate relationship among food safety culture and *L. monocytogenes* contamination. The overall finding from this study is combined with our previous *L. monocytogenes* study in retail produce environments (Wu et al., 2020), as illustrated in Figure 3.1. Our survey tool primarily measured food safety culture, but certain survey questions asked perceptions on the leadership and workplace specifically targeting food safety climate (De Boeck et al., 2015). Principal component analysis identified two primary dimensions of our survey, namely "organizational climate," encompassing sense of commitment to food safety program, perception on employees' training, and food safety climate, and "individual's behavior", for individual hygiene and handwashing (Table 3.1). This highlights food safety culture as discrete yet interconnected component to retail food safety. Our data indicate that (i) there was a strong association between food safety culture and *L. monocytogenes* contamination risk in retail delis, (ii) deep clean significantly improved short- and long-term food safety culture, (iii) differences in

perception of food safety programs existed between retail deli management and employment, and (iv) personal hygiene and handwashing behaviors exhibited mixed outcomes.

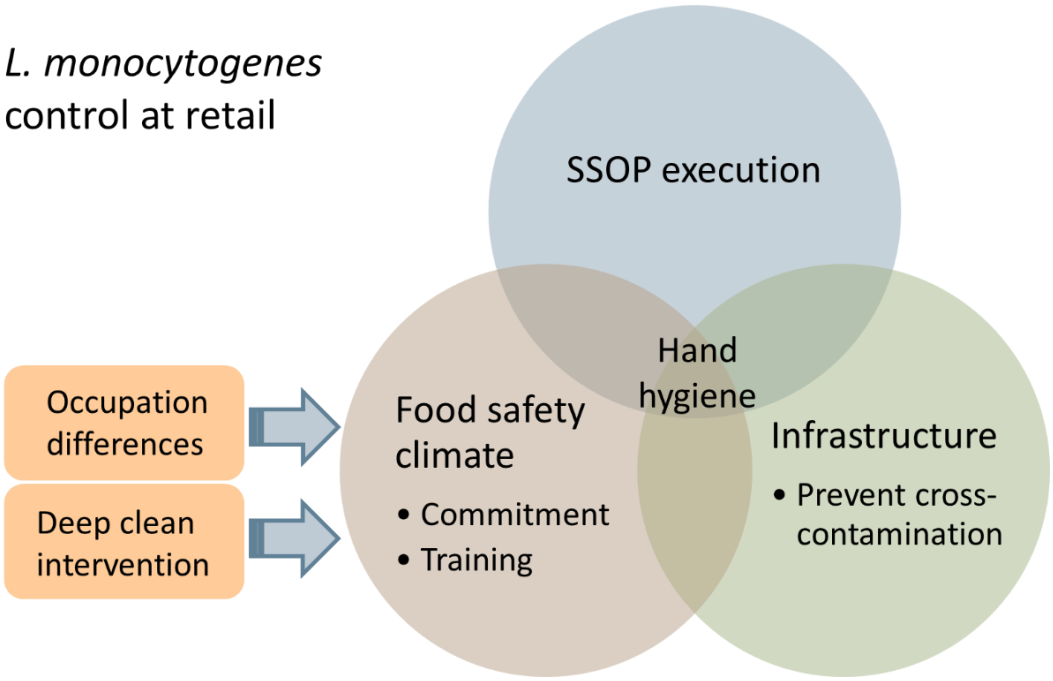

Figure 3.1. Venn diagram of key factors' interaction in food safety culture in retail environments.

Table 3.1. Principal component analysis of survey questions. Decimal values represent correlation of each survey variable to the two principal components, "organizational climate" and "individual behavior". Correlation greater than 0.40 is considered significant.

Survey question[a]	Question identifier[b]	Organizational climate[c]
Management shows leadership by keeping employees focused on food safety.	Q4_32	0.83
Management makes sure employees follow food safety rules all the time.	Q4_8	0.80
Management encourages employees to report all food safety problems.	Q4_30	0.78
Management follows all the food safety rules in the restaurant.	Q4_34	0.78
Management provides adequate-tools for training and/or education for food safety.	Q4_35	0.77
Management visibly shows support for food safety ("walks the talk").	Q4_33	0.77
Management often checks to see that all employees are following the food safety rules.	Q4_11	0.77
Employees encourage each other to follow food safety rules.	Q4_2	0.74
Employees take responsibility for proper food handling in their work areas.	Q4_3	0.73
Management at this restaurant follows the food safety rules.	Q5_1	0.73
Employees are committed to the food safety program.	Q4_1	0.71
New employees receive all the training they need to perform their jobs according to food safety rules.	Q4_28	0.71
Employees receive the proper training to follow the food safety rules.	Q4_27	0.71
Employees at this restaurant follow the food safety rules.	Q5_2	0.71
Even if no one was looking, employees would follow all the food safety rules.	Q4_5	0.69
Management stresses food safety rules even when the restaurant is busy.	Q4_9	0.69
Management praises employees who pay special attention to food safety.	Q4_12	0.68
The organization learns and makes changes when mistakes are found in food safety.	Q4_36	0.67
Employees will tell a manager when a food safety problem happens.	Q4_4	0.67
Management believes that food safety is very important.	Q4_31	0.66
Management makes sure employees have the equipment and/or tools needed to follow the food safety rules.	Q4_10	0.66
Even if no one was looking, management would follow all the food safety rules.	Q4_15	0.61

Table 3.1 continued

Survey question[a]	Question identifier[b]	Individual behavior[c]
The food safety training provided gives us the necessary skills and/or knowledge to follow the food safety rules.	Q4_29	0.59
Management is committed to serving safe food.	Q4_7	0.59
Management asks for help from employees to improve our food safety program.	Q4_19	0.54
Employees chew gum or eat snacks in the kitchen.	Q5_4_rc (reverse coded)	0.50
Employees do not washing their hands when they can get away with it.	Q5_5_rc	0.48
Employees do things that contaminate food by not following food safety rules.	Q5_3_rc	0.48
Equipment is designed to allow for proper cleaning.	Q4_37	0.46
Management sometimes looks the other way when employees are not following food safety rules.	Q4_14_rc	0.42
I know why I should change my gloves to protect the food from contamination.	Q4_26	0.95
I know why I should wash my hands to protect the food from contamination.	Q4_17	0.95
I know when I should change my gloves to protect the food from contamination.	Q4_25	0.92
I know when I should wash my hands to protect the food from contamination.	Q4_16	0.91
I know food safety problems can happen if I do not do my job correctly.	Q4_24	0.85
I believe that how well I do my job can affect the safety of the food the customer receives.	Q4_22	0.84
I believe it is important for me to follow all the food safety rules, not just the most important ones.	Q4_21	0.80
I always consider food safety when I am doing my job.	Q4_20	0.76
I completely support our food safety program.	Q4_23	0.75
When the restaurant is busy, I still wash my hands as much as I should.	Q4_18	0.72

[a] All survey questions that formed the two principal components from the principal component analysis using Promax rotation;
[b] Question identifiers corresponding to the survey questions;
[c] Principal components that clustered from the correlation between the observed survey variables to the principal components.

3.4.1 Greater commitment to food safety was reported from delis with lower *L. monocytogenes* contamination risk

Employees' and management's commitment to food safety programs correlated with *L. monocytogenes* contamination risk. At the store level, associates perceived management's commitment to food safety to be significantly better in delis with low *L. monocytogenes* risk compared to high-risk delis (p_{adj}=0.0317). The same trend was marginally significant regarding associates' perception of management showing visible support for food safety programs (p_{adj}=0.0516).

Employees' and management's commitment are an integral component to building a sustainable food safety program. Factors such as accountability, management presence, and peer influence have been identified as pivotal elements in characterizing and measuring food safety culture (Arendt et al., 2014). In retail produce environments, handwashing negligence was significantly correlated with higher *L. monocytogenes* prevalence, indicating commitment to basic hygiene is a major risk factor in *L. monocytogenes* control (Wu et al., submitted). In addition to being aware of and committed to food safety regulations, management strategies and effective communication also facilitate establishment of a sustainable food safety core value (Arendt et al., 2014; Griffith et al., 2010; Powell et al., 2011). Specifically, an interactive, approachable management style and an organization that promotes information distribution and feedback greatly enhance food safety execution and potentially reduce food safety risk (Arendt et al., 2014; Neal et al., 2012; Powell et al., 2011). While management's effort is often ascribed with great significance in pushing forward food safety, Powell et al. (2013) also concluded that a unidirectional top-down model of audit- and inspection-based food safety management is not enough due to multiple constrains, including competence of auditors, scope of the inspection, snapshot record, reliability of audit tools. Therefore, verification and more robust programs should be implemented to ensure food safety. Indeed, personal behaviors and environmental hygiene directly impact food safety status (Hoelzer et al., 2011; Montville, Chen, & Schaffner, 2001; Stedefeldt et al., 2015). A salmonellosis outbreak from peanut products was attributed to the lack of food safety culture, including inadequate cleaning and sanitizing, lack of testing roasting temperatures, etc. (Powell et al., 2011). Powell et al. (2011) further stated that nurturing a healthy food safety culture was fundamental in improving front-line behaviors. Food safety climate and culture have been investigated in multiple settings including street vendors (Cortese et al., 2016; Trafialek et al.,

2018), universities (Al-Shabib, Mosilhey, and Husain, 2016; Lee et al., 2017), and processing facilities (Ansari-Lari, Soodbakhsh, and Lakzadeh, 2010; Zanin et al., 2015). Multiple studies have found that self-reported knowledge and commitment often do not translate into proper food safety practices during food processing (Ansari-Lari, Soodbakhsh, and Lakzadeh, 2010; Pacholewicz et al., 2016; Zanin et al., 2015) or in food service (Al-Shabib, Mosilhey, and Husain, 2016; Faour-Klingbeil, Kuri, and Todd, 2015; Lee et al., 2017; Rebouças et al., 2017). Our data suggest a significant correlation between greater self-reported commitment and lower *L. monocytogenes* contamination risk in retail deli environments, demonstrating a fundamental role of valuing food safety in *L. monocytogenes* control.

3.4.2 Employee training programs were perceived to be better in delis of low *L. monocytogenes* risk

Analyses of the surveys from each respondent revealed a strong association between better perception of employee training programs and reduced *L. monocytogenes* contamination risk. Within stores of low *L. monocytogenes* risk, employees and management were more likely to perceive their training program covering all that was needed to perform their tasks for new employees ($p=0.0117$), and providing skills and/or knowledge necessary to follow food safety regulations ($p=0.0177$) (Table 3.2, Appendix H). Employee training is critical to maintaining food safety climate and culture (Arendt et al., 2014; Kim et al., 2013; Neal et al., 2012; Robertson et al., 2013; Strohbehn et al., 2014) and personal hygiene among all employees (Green et al., 2007; Soarse et al., 2013). The role of training becomes more important in monitoring food safety hazards and risk given the high employee turnover rate (Grujic et al., 2010; Kim et al., 2013). According to Arendt et al. (2015), "knowledge and training" is one of the most significant factors motivating employees to comply with food safety rules. However, as several studies reported that training alone does not improve either food safety behaviors (Hammons et al., 2017; Pilling et al., 2008; Webb and Morancie, 2015) or sense of commitment to these behaviors (Fatimah, Strohbehn, and Arendt, 2014); additional barriers exist in conveying training materials and programs. Indeed, "lack of knowledge", "consequence", and "availability of resources" have been identified as barriers among food handlers in both commercial and non-commercial establishments (Arendt et al., 2015), suggesting inadequacies and gaps need to be addressed to improve employees' training toward construction of a sustainable food safety culture.

Table 3.2. Significant survey variables grouped by effects.

ID[a]	Outcomes[b]	p value[c]
***L. monocytogenes* contamination risk**		
Q4_28	Training for new employees reported more likely to cover all that they need to perform their jobs according to food safety rules in delis of low *L. monocytogenes* risk than those of high risk.	0.0117
Q4_29	Food safety training reported more likely to provide "us" the necessary skills and/or knowledge to follow the food safety rules in delis of low *L. monocytogenes* risk than those of high risk.	0.0177
Period		
Q4_1	Employees reported to have greater commitment to food safety program during follow-up than immediately before deep clean (p_{adj}=0.0057).	0.0112
Q4_3	Employees reported to take greater responsibility for proper food handling in their work area during follow-up than immediately before deep clean (p_{adj}=0.0103).	0.0198
Q4_4	Employees reported a greater likelihood to tell a manager when a food safety problem happened during follow-up than immediately before deep clean (p_{adj}=0.0022).	0.0043
Q4_5	Employees reported more likely to follow all food safety rules even if no one was looking during follow-up than immediately before deep clean (p_{adj}=0.0055).	0.0108
Q4_10	Management was more likely to make sure employees have the equipment and/or tools needed to follow the food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0243).	0.0378
Q4_12	Management was more likely to praise employees who pay special attention to food safety during follow-up than immediately before deep clean (p_{adj}<0.0001).	0.0002
Q4_18[†]	Participants were more likely to agree that "I still washed my hands as much as I should when it was busy" immediately before deep clean than immediately after deep clean (p_{adj}=0.0356).	0.0055
Q4_27	Employees reported more likely to receive the proper training to follow the food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0291).	0.0444
Q4_28	Training for new employees was reported more likely to cover all that they needed to perform their jobs according to food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0053).	0.0068
Q5_2	Employees at the workplace reported more likely to follow the food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0004).	0.0004
Q5_3_rc	Employees reported more likely to not follow food safety rules and contaminate food immediately before deep clean than during follow-up (p_{adj}=0.0160).	0.0183
Q5_5_rc	Employees reported more likely to not wash their hands when they can get away with it immediately before deep clean than during follow-up (p_{adj}=0.0034).	0.0035
***L. monocytogenes* contamination risk across study period**		
Q4_1	In delis of high *L. monocytogenes* risk, employees reported to have greater commitment to food safety program during follow-up than immediately before deep clean (p_{adj}=0.0165).	0.0038
Q4_5	In delis of high *L. monocytogenes* risk, employees reported more likely to follow all food safety rules even if no one was looking during follow-up than immediately before deep clean (p_{adj}=0.0367).	0.0049

Table 3.2 continued

Occupational position differences		
Q4_2	Associates reported "employees more likely to encourage each other to follow food safety rules" than their managers did.	0.0168
Q4_3	Associates reported "employees more likely to take responsibility for proper food handling in their work areas" than their managers did.	0.0129
Q4_5	Associates reported "employees were more likely to follow all the food safety rules even if no one was looking" than their managers did.	0.0200
Q4_12	Managers reported "management more likely to praise employees who pay special attention to food safety" than their associates did.	0.0317
Q4_28	Associates reported "new employees more likely to receive all training they needed to perform their jobs according to food safety rules" than their managers did.	0.0076
Q4_37	Associates reported "equipment more likely to be designed for proper cleaning" than their managers did.	0.0127
Occupational position differences across periods		
Q4_7	"Management is committed to serving safe food": Nature of effect unclear.	0.0385
Q4_19	"Management asks for help from employees to improve our food safety program": Nature of effect unclear.	0.0376
Q4_26[†]	"I know why I should change my gloves to protect the food from contamination": Nature of effect unclear.	0.0489
Q4_27	Associates were more likely to agree that "employees receive the proper training to follow the food safety rules" during follow-up than immediately before deep clean (p_{adj}=0.0001). During follow-up, associates were more likely to agree that "employees receive the proper training to follow the food safety rules" than managers did (p_{adj}=0.0078).	0.0125
Q4_29	Associates were more likely to agree that "food safety training gives us the necessary skills and/or knowledge to follow the food safety rules" during follow-up than immediately before deep clean (p_{adj}=0.0007).	0.0342

[a] All survey questions that were reported significant under designated effect with $p<0.05$, [†] designated to the question under "individual's behavior" factor from principal component analysis, all else questions are under "organizational climate" factor;
[b] Context of the significant effects based on correlation analysis, Bonferroni adjustment was applied for multiple comparisons for effect "period", "LM risk*period", and "occupation*period";
[c] Unadjusted p-values of each significant variables ($p<0.05$).

A review article by Neal and Sirsat (2015) reported that food safety training programs should include behavior-based training. For instance, training programs should emphasize reducing cross-contamination and center upon behavior change to improve personal hygiene, such as basic hand washing (Neal and Sirsat, 2015). However, in a complex, fast paced retail environment, food handlers may not have enough time to allow them to comply to all food safety rules (Arendt et al., 2015; Strohbehn et al., 2014). Training methods focusing on risk reduction and employee empowerment have been articulated as a means to cultivate a sustainable food safety

culture (Robertson et al., 2013). According to a recent review by Lakicevic and Nastasijevic (2017), an effective training program is also crucial for *L. monocytogenes* control. Consistent with previous findings, our study found that employee training is an important factor in food safety monitoring as well as *L. monocytogenes* control; concerns regarding training format and delivery warrant further study. Our data also illustrate the critical role of training in attenuating *L. monocytogenes* prevalence in retail deli environments. Further investigation on specific parameters of an effective training program in *L. monocytogenes* control should be conducted.

3.4.3 Deep clean significantly improved perceptions on commitment to a food safety program and employee training

There was a significant long-term improvement in self-reported commitment to food safety programs among retail deli associates and managers before the deep clean and during the follow-up period. Both associates and managers reported higher levels of commitment long-term after the deep clean event (p_{adj}=0.0057). This includes associates reporting food safety problems (p_{adj}=0.0022), associates taking responsibility for proper food handling (p_{adj}=0.0103), and associates following food safety rules even without managerial presence (p_{adj}=0.0055) (Table 3.2, Appendix I), particularly in the seven high risk facilities regarding associates' commitment (p_{adj}=0.0165) and their food safety compliance (p_{adj}=0.0367) (Table 3.2, Appendix J). At the store level, a significant improvement in employee commitment to food safety was reported immediately after the deep clean compared to immediately before (p_{adj}=0.0337). Associates reported an immediate commitment improvement when analyzed using *L. monocytogenes* prevalence in percentage (as opposed to *L. monocytogenes* binary contamination risk) (p_{adj}=0.0265, Appendix K).

Employee perception of management's commitment to food safety was also significantly improved before deep cleaning and during the follow-up period. Additionally, during the follow-up survey, both associates and managers reported management as more readily providing employees with the necessary tools to follow food safety regulations (p_{adj}=0.0243) and were also more likely to praise associates who pay special attention to food safety (p_{adj}<0.0001) than before the deep clean (Table 3.2, Appendix I). At the store level, there were significant immediate (p_{adj}=0.0429) and long-term (p_{adj}=0.0094) improvements in the perception of management's commitment to asking for employees to assist in improving food safety programs. There was a

long-term improvement in the perception of "employees receive proper training" (p_{adj}=0.0291) and "new employees receive all the training needed to perform their job according to food safety rules" (p_{adj}=0.0053) post- versus pre-deep clean.

Commitment to training and attitude set the foundation of a healthy food safety culture and environment. Previous deep clean studies at retail reported mixed results in *L. monocytogenes* control after revising SSOPs (Etter et al., 2017; Hammons et al., 2017; Wu et al., accepted). Similarly, Soon et al. (2012) reported a gap between food handlers' self-reported attitudes toward food safety and training in food processing and retail settings, therefore the implemented training plan had minimal impact. On the other hand, Dudeja et al. (2017) reported a positive impact of implementation of a food safety training manual on knowledge, attitude, and practices in foodservice. Furthermore, several studies have concluded that food safety knowledge did not translate into behavior (Ansari-Lari, Soodbakhsh, and Lakzadeh, 2010; Lee et al., 2017), signaling a need to seek additional means that can bridge the gap and motivate tangible, behavioral change. While training is crucial, retraining is also needed to improve food safety knowledge (McIntyre, Peng, and Henderson, 2014) and maintain food safety behaviors (De Boeck et al., 2016). Our data suggest that the employee- and management-implemented deep clean can improve the long-term commitment level of retail deli employees and management, especially those working in delis with high *L. monocytogenes* contamination risk. Indeed, deep cleans conducted by retail establishments' own employees (Wu et al., accepted) yielded a more successful outcome compared to those performed by a third-party company (Hammons et al., 2017), likely indicating the importance of employees' participation in constructing a more sustainable food safety culture. This result demonstrates the improved awareness and value of deep cleans to deli staff in both low- and high-risk conditions. Further studies are needed to verify whether the improved commitment was translated into proper food safety practices.

3.4.4 Perceptions on hand hygiene had mixed outcomes

The survey asked if "employees do not wash their hands when they can get away with it", to which participants reported a significantly higher likelihood to wash their hands during post-deep clean follow-up, compared to pre-deep clean (p_{adj}=0.0034). However, as the question was positively keyed as "I still wash my hands as much as I should when it is busy", respondents were more readily to perceive a greater handwashing compliance during pre-deep clean than

immediately post-deep clean (p_{adj}=0.0356) (Table 3.2, Appendix I). Thus, phrasing of the question affected participants' responses. In the analysis with *L. monocytogenes* prevalence percentage, an immediate improvement in handwashing behavior and personal hygiene was reported post-deep clean. Specifically, managers and employees were more likely to report that they still follow all hand washing protocols when the store is busy (p_{adj}=0.0294) and that they believe it is important to follow all food safety protocols (p_{adj}=0.0063) immediately post-deep clean when compared to before cleaning (Appendix K). At the store level, perception on handwashing had significant differential between occupational positions. Deli associates perceived "handwashing compliance during busy hours" significantly better compared to the management counterpart in stores of low *L. monocytogenes* risk (p_{adj}=0.0180). Counterintuitively, management from low-risk delis reported lower handwashing compliance during busy hours compared to delis of high *L. monocytogenes* risk (p_{adj}=0.0339). Overall, perception of handwashing had mixed results based on the wording of the questions. Future studies should take caution on question phrasing as not to lead respondents to a specific answer; observational studies may be more suitable and authentic in studying personal hygiene and handwashing behaviors.

Handwashing is fundamental to food safety culture. Inadequate handwashing is directly linked to food contamination (Conover and Gibson, 2016; Lubran et al., 2010) and *L. monocytogenes* transmission (Lakicevic and Nastasijevic, 2017; Tabit, 2018; Wu et al., 2020). However, handwashing compliance is limited based on previous surveys and observational studies (Green et al., 2007; Strohbehn et al., 2008). According to Green et al. (2006, 2007), food handlers in restaurants were more likely to wash their hands during food preparation than handling dirty equipment and touching their body parts. While glove usage does not substitute for handwashing (Conover and Gibson, 2016; Montville, Chen, and Schaffner., 2001), handwashing frequency was significantly less during gloved operations (Green et al., 2006) demonstrating potential risk of cross-contamination. Handwashing compliance tends to be skewed by study participants' tendency to over-report (Green et al., 2005; Lubran et al., 2010). A recent observational study at retail grocery stores and restaurants showed low handwashing compliance (Choi et al., 2016). Although all participating facilities had handwashing stations in place (Choi et al., 2016), poor hand hygiene reflected additional factors other than resources provided. Indeed, work pace, negligence, and other organizational obstacles can also contribute to the challenge (Arendt et al., 2015; Strohbehn

et al., 2014) resulting in deli employees not having enough time and/or resources to complete necessary food safety tasks.

3.4.5 Significant variations between occupational positions were observed for perceived commitment, employee training programs, and infrastructure design

Associates self-reported to be more devoted to their food safety program than their managers perceived them to be. Specifically, associates responded that they were likely to follow food safety rules without managerial presence (p=0.0200), they take more responsibility for proper food handling (p=0.0129), and encourage each other to follow food safety rules (p=0.0168). The same trend was also present among stores with low *L. monocytogenes* risk at the store level (p_{adj}=0.0434). Alternatively, managers perceived themselves as having greater commitment to food safety than how their employees perceived their managers. Management reported that they were more likely to praise employees who pay special attention to food safety than how associates perceived them (p=0.0317) (Table 3.2, Appendix L). Associates also had a better perception than their managers that new employee training programs were capable of providing the knowledge and skills needed to perform their jobs according to food safety rules (p=0.0076). Similarly, associates reported improved training during the follow-up period after deep clean (p_{adj}=0.0078) compared to management (Table 3.2, Appendix L). Studies have identified knowledge gaps within a food business both laterally within a level of employment and vertically between employees and managers (Nayak and Waterson, 2017; Rowell et al., 2013), indicating potential inadequate communication within the organization. Micro-culture (the segregation within one organization into smaller sections and units), for example, can pose as a salient challenge to food safety culture and management (Nayak and Waterson, 2017). Moreover, as training exhibited limited impact on improving food safety performance (Pilling et al., 2008; Webb and Morancie, 2015; Rowell et al., 2013), methods to verify food safety culture are crucial to not only sustain a healthy, effective food safety program, but also narrow the gap between the hierarchy in the establishment.

Associates were more likely to believe equipment design allowed for efficient cleaning than their managers did (p=0.0127) (Table 3.2, Appendix L). Analysis at the store level also suggested a more positive perception of equipment cleanability during pre-deep clean among deli associates compared to management (p_{adj}=0.0053). Cleanability and accessibility of equipment is critical in ensuring food safety and controlling *L. monocytogenes* prevalence (Wu et al., 2020).

Strohbehn et al. (2014) has suggested to improve workplace accessibility by, for instance, rearranging items to bring them closer to the work location, hence avoiding additional traffic and risk to cross-contaminate.

The deep clean had a differential influence on deli associates' and managers' perceptions, including long-term improvement among associates regarding the comprehensiveness (p_{adj}=0.0007) and adequacy (p_{adj}=0.0001) of the training program (Table 3.2, Appendix L).Taken together, while it may be natural for managers and associates to perceive the same food safety environment quite differently, there is a need to flatten the hierarchy between associates and managers, and bridge the perception gaps between the two positions to reduce miscommunication and misconception.

3.4.6 Study limitations

Our study investigates the relationship between human factors and pathogen prevalence in retail deli environments. Resources limited longitudinal *L. monocytogenes* environmental samples to stores with high contamination risk therefore stores with low-risk are under-represented. Given multiple analyses on both the individual and store level using *L. monocytogenes* binary risk, the limited low-prevalence data would likely not change with our overarching conclusions and the trend would remain largely the same. We used a modified survey developed and tested in institutional foodservice settings by Neal et al. (2012). After use in retail delis, there are questions that may be redundant and some aspects warrant further refinement. Additionally, Nyarugwe et al. (2018) suggested using multiple methods to enhance the credibility and strength of food safety culture study. Ideally, future human subject research, such as food safety climate and culture studies, can include multiple approaches in its analysis paradigm to better capture the cultural and organizational complexity. Despite these shortcomings, our study offers valuable insights that pave ways for further investigations of human dynamics and food safety culture at retail.

3.5 Conclusions

This study found that a stronger food safety culture, especially greater managers' and employees' commitment, better perception of the training program, and infrastructure was significantly associated with lower *L. monocytogenes* contamination risk. This result confirms

previous studies on food safety culture as a risk factor (Arendt et al., 2014; Jespersen, Griffiths and Wallace, 2017; Strohbehn et al., 2014), demonstrating the fundamental importance of value, commitment, and hygiene, which are intimately related to food safety and *L. monocytogenes* prevalence and control. We found that deep clean significantly improved food safety culture both short- and long-term. Additionally, there was a salient dichotomy between management and employment on perceiving food safety program, including sense of commitment, employees' training program, and infrastructure cleanability. Deli managers and associates also responded differently to the deep clean, especially toward training programs, where associates' perception was more readily improved long-term than their managers'. Indeed, as values and knowledge may not be readily translated into behaviors (Ansari-Lari, Soodbakhsh, and Lakzadeh, 2010; Lee et al., 2017), future efforts should be directed to investigate the intricate dynamics and methods to sustainably improve food safety culture through verification, real-time tracking, and providing feedback to promote behavioral change.

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CHAPTER 4. INFRASTRUCTURE, SANITATION, AND MANAGEMENT PRACTICES IMPACT *LISTERIA MONOCYTOGENES* PREVALENCE IN RETAIL GROCERY PRODUCE ENVIRONMENTS

4.1 Abstract

We designed and implemented a comprehensive survey of facilities, management practices, and cleaning and sanitizing frequencies in 30 United States grocery retail produce departments to evaluate *Listeria monocytogenes* control strategies. Produce department managers completed the survey during a six-month longitudinal study of *L. monocytogenes* on food and non-food contact surfaces in retail produce departments. *L. monocytogenes* prevalence in each store was compared to survey responses both overall and by surface type. Pearson correlation and ANOVA were used to identify significant survey variables associated with *L. monocytogenes* prevalence. Tukey pairwise comparisons were conducted to elucidate the nature of significant effects (α=0.05). Pooled water near misted produce case drain covers and lack of disposable glove changing oversight after touching non-food-contact surfaces (NFCS) significantly correlated with higher *L. monocytogenes* prevalence overall (p=0.01, p=0.002), on food-contact surfaces (FCS; p=0.001, p=0.01) and NFCS (p=0.04, p=0.003). Cleanability of bottom dry produce shelf, changing gloves after handling each type of produce, and selecting lateral role models among employment strongly correlated with lower *L. monocytogenes* prevalence overall (p=0.02, p=0.01, p=0.01) and on NFCS (p=0.02, p=0.011, p=0.01). Mixed results were found regarding inter-departmental traffic and cleaning time and frequency. General linear regression demonstrated a notable effect by 7 predictor variables synergistically upon *L. monocytogenes* prevalence (p=0.0001 for overall, p=0.0007 for FCS, p=0.001 for NFCS). This is the first study to investigate the impact of facility design and management practices on *L. monocytogenes* prevalence in retail produce environments.

4.2 Introduction

Listeria monocytogenes is among the leading causes of foodborne-related death in the United States, responsible for approximately 1600 listeriosis incidents and 260 deaths per year (Centers for Disease Control and Prevention (CDC), 2016a; Scallan et al., 2011). Retail establishments are predicted to play an important role in *L. monocytogenes* transmission to humans

(Hoelzer et al., 2011); retail delicatessen (referred to hereafter as "deli") departments in particular have been implicated as a significant reservoir (Hoelzer et al., 2011; Simmons et al., 2014; U.S. Food and Drug Administration (FDA), 2013). In recent years, fresh produce-related *L. monocytogenes* outbreaks have increased in frequency and are recognized as a serious public health concern (Buchanan et al., 2017; CDC, 2016b; Zhu, Gooneratne, & Hussain, 2017); grocery stores and retailers were addressed as key checkpoints during produce transportation and distribution (CDC, 2012, 2015). In 2011, a multistate listeriosis outbreak in the U.S. caused by contaminated cantaloupe resulted in 33 listeriosis-related deaths (CDC, 2012). More recently, bean sprouts distributed primarily via restaurants and retail chains caused an outbreak that resulted in two deaths and five hospitalizations (CDC, 2015). *L. monocytogenes* contaminated produce was also reported in retail environments in Malaysia (Ponniah et al., 2010).

In our recent environmental study of 30 U.S. retail produce departments, we found that average *L. monocytogenes* prevalence was approximately 4.4% (226/5112), with 8.1% (178/2205) prevalence on non-food contact surfaces (NFCS) and 1.7% (48/2907) prevalence on food contact surfaces (FCS) (Burnett et al., submitted). These data suggest there is possible cross-contamination at the retail level that could result in contaminated foods. Facility characteristics, management practices, and sanitation are crucial to maintaining food safety practices (Griffith, Livesey, & Clayton, 2010; Miller, 2009); these factors significantly impact *L. monocytogenes* prevalence in retail deli environments (Wang, 2014). To our knowledge, there is no comprehensive study of practices that influence *L. monocytogenes* prevalence and persistence in retail produce handling and storage environments. We hypothesized that facility characteristics, management strategies, and sanitation practices impacted *L. monocytogenes* prevalence in retail produce environments. In this study we asked 30 retail grocery produce managers to define these characteristics in stores that were enrolled in a longitudinal *L. monocytogenes* environmental monitoring program (Burnett et al., submitted) to investigate the relationships among facility characteristics, management strategies, sanitation practices, and *L. monocytogenes* prevalence.

4.3 Materials and Methods

4.3.1 Facility design and management practices survey development

We developed a survey based on our previous work in deli establishments (Wang, 2014). Modifications were made based on the FDA Food Code (2013), FDA draft guidance on *L. monocytogenes* control in ready-to-eat foods (2017), *Guide to Food Safety* (McSwane, Linton, & Rue, 2010), and initial *L. monocytogenes* prevalence data from concurrent environmental sampling in 30 retail produce departments (Burnett et al., submitted). Facility and equipment design advised practices to reduce *L. monocytogenes* prevalence, and potential *L. monocytogenes* harborage sites were considered and formed the fundamental themes of the survey: "facility design", "management practices", and "cleaning and sanitation frequencies". These three categories were not identified in the questionnaire but were used in subsequent result interpretation. A pilot of the survey was conducted with five retail produce managers whose stores were not participating in the longitudinal prevalence study. Four additional feedback questions addressing unclear question intent, survey length, and preferred distribution method were included at the end of the pilot survey. After modifications, the final survey was composed of 110 questions: 14, 55, and 41 questions on facilities, management practices, and cleaning and sanitation frequencies, respectively. These 110 questions were prioritized with what predicted to be the most relevant questions positioned towards the beginning of the survey. The order of questions was not randomized as many were logically interdependent.

4.3.2 Survey participants and data collection

Prior to the study, the protocol and survey were approved by Purdue University Institutional Review Board (protocol# 1509016474). Thirty retail produce department managers from seven U.S. states were recruited to take the survey; managers were from stores enrolled in a *L. monocytogenes* environmental sampling study (Burnett et al., submitted). Both the pilot and formal surveys were distributed via email containing a personalized link generated by Qualtrics (Qualtrics, Provo, UT) (Appendix M). Pop-up confirmation was enabled on Qualtrics if participants proceeded without completing the page to ensure full response. The participants were able to pause and resume the survey. Mail was the alternative means of distribution. Distribution date ranged from early October to mid-late December 2016; data collection was positioned to

avoid busy holiday seasons. Survey responses were matched with the store and its corresponding *L. monocytogenes* prevalence as calculated from the concurrent *L. monocytogenes* longitudinal environmental sampling (Burnett et al., submitted).

4.3.3 Statistical analyses

All statistical analyses were performed in SAS 9.4 (SAS Institute, Cary, NC). Power analysis was performed by Proc Power procedure (α=0.05). The 110 survey questions were categorized as continuous or categorical. Each question was treated as a predictor variable and correlated with *L. monocytogenes* prevalence on FCS, NFCS, and both surface types (Burnett et al., submitted) using Pearson correlation for continuous variables, and ANOVA for categorical variables (α=0.05). Significant categorical variables were selected for subsequent Tukey pairwise comparison to elucidate the nature of the effect. Cross tabulation was performed to visualize the correlation between significant predictor variables and *L. monocytogenes* prevalence overall and on NFCS (α=0.05); prevalence on FCS was not included since there was only one store with "high" prevalence. Prevalence categories were defined as <1% being "low" prevalence, 1%-10% being "moderate", and >10% being "high" (Burnett et al., submitted; Simmons et al., 2014). To detect the significant factors under synergistic contexts, all significant predictor variables were regressed simultaneously with *L. monocytogenes* prevalence by surface types to fit a general linear model via Proc GLM. Multicollinearity analysis was subsequently performed by 1) Pearson correlation between continuous variables, 2) Fisher's Exact Test among categorical variables, and 3) ANOVA followed by Tukey pairwise comparison between continuous and categorical variables to examine the strength of our model (α=0.05).

4.4 Results and Discussion

All thirty distributed surveys were returned and fully completed. The purpose of this study was to predict risk factors and identify feasible interventions to improve infrastructures, and management and sanitation practices in retail produce handling and storage environments with the goal of controlling *L. monocytogenes*. We found that i) glove changing and hand hygiene management were the most fundamental in *L. monocytogenes* control; ii) efficient sanitation program management and proper execution of SSOPs strongly correlated with reduced *L.*

monocytogenes prevalence; and iii) infrastructures should be designed to maximize accessibility for storage and cleaning, preventing pooled/standing water, and minimize inter-departmental traffic. Analysis of each risk factor is based on correlating individual predictor variables discretely to *L. monocytogenes* prevalence.

4.4.1 Seven factors were independently consequential in a general linear regression model that overall significantly impacted *L. monocytogenes* prevalence

Pre-selected significant survey questions from correlation analysis were regressed simultaneously with *L. monocytogenes* prevalence on both surface types, FCS, and NFCS, respectively ($\alpha<0.05$) (Table 4.1). Untransformed prevalence data fitted general linear model with $r^2=0.96$ and MSE=3.76 for both surface types, $r^2=0.93$ and MSE=1.21 for FCS, and $r^2=0.99$ and MSE=5.64 for NFCS (Figure 4.1, 4.2, 4.3; Appendix N). Overall, the model was significant with p=0.0001 for both surface types, p=0.0007 for FCS, and p=0.001 for NFCS. Additionally, seven factors continued to exhibit significance in the regression model (Table 4.2). Our data indicate that the theme of *L. monocytogenes* control in retail produce environments resides chiefly in glove management, standing or pooled water, cleaning frequency and duration, and inter-departmental traffic. These results had a power greater than 0.9 ($\alpha=0.05$), suggesting high statistical confidence in not only the significant synergistic effect of pre-selected predictor variables on *L. monocytogenes* prevalence, but also the independent significance of the seven survey questions. Our model is adequate for understanding *L. monocytogenes* dynamics and developing intervention strategies in retail produce environments from the approach of facility, management, and cleaning and sanitizing practices, and is discussed in greater detail below.

Table 4.1. Significant predictor variables of *L. monocytogenes* prevalence by surface type ($\alpha<0.05$).

Identifier [a]	**Question** [b]	**Outcome ($p_{adj}<0.05$)** [c]	**p value** [d]
Q9_1	Does management method actively promote food safety behavior among produce area employees via selecting role models from employees who best follow food safety rules?	No lateral peer role models in employment structure was correlated with higher prevalence	NFCS: 0.0139 Both: 0.0128
Q13_1	Do workers from bakery departments walk through the produce area during their work?	Bakery employees walking through produce area was correlated with lower prevalence	FCS: 0.0118
Q13_3	Do workers from deli departments walk through the produce area during their work?	Deli employees walking through produce area was correlated with lower prevalence	FCS: 0.0083 Both: 0.0243
Q15_3	Do produce area employees walk through deli departments during their work?	Produce employees walking through deli was correlated with lower prevalence	FCS: 0.0432
Q15_8	Do produce area employees walk through departments other than bakery, dairy, deli, grocery, prepared food, raw meat, and seafood, during their work?	Produce employees walking through said departments was correlated with higher prevalence	NFCS: 0.0285 Both: 0.0394
Q19	Are disposable gloves changed after touching non-food-contact surfaces (e.g., cart handles, hand wash sink basin, drain cover, etc.)?	Management being unaware glove changing was correlated with higher prevalence compared to 1) being aware of glove status (FCS, NFCS, Both); 2) missing response (NFCS, Both)	FCS: 0.0125 NFCS: 0.0030 Both: 0.0015
Q23	When are floor surfaces in the produce preparing area cleaned relative to other areas in the produce prepare area?	Nature of correlation not clear	FCS: 0.0087
Q33_4	Is bottom shelf level holding dry produce of the produce area difficult to clean?	Inaccessible bottom shelf for cleaning was correlated with higher prevalence	NFCS: 0.0249 Both: 0.0217
Q38	Does water pool near misted produce case drain cover in produce retail area?	Presence of water pooled was correlated with higher prevalence compared to 1) no present pool (FCS, NFCS, Both); 2) not knowing if pooled water present (FCS)	FCS: 0.0013 NFCS: 0.0414 Both: 0.0125

Table 4.1 continued

Q40	Approximately how many employees, on average, work during one single shift in the produce area (both preparing area and retail area)?	Increased number of employees was correlated with higher prevalence	NFCS: 0.0377
Q53	How many hours a day are dedicated to cleaning tasks at the end of the day after the produce preparing area has closed?	Increased number of hours was correlated with higher prevalence	FCS: 0.0003 NFCS: 0.0156 Both: 0.0038
Q56	How often, on average, do associates change gloves?	Changing gloves once per hour was correlated with higher prevalence compared to changing after each type of produce	NFCS: 0.0110 Both: 0.0114
Q83_2	Are scrub brushes used to clean and sanitize the floor of produce retail area?	Not using scrub brushes was correlated with higher prevalence	NFCS: 0.0423
Q84_3	Are mops used to clean and sanitize the floor of produce prepare area?	Not using mops was correlated with higher prevalence	FCS: 0.0309
Q102	How often are food contact surfaces of produce retail case cleaned?	Cleaning once every 2-4 days was correlated with higher prevalence compared to cleaning 1) once per 4 hours; 2) once daily; 3) once per 2 weeks; 4) once per month; 5) less than once per month	NFCS: 0.0015 Both: 0.0029
Q110	How often are scale surfaces (food contact surface) are cleaned and sanitized?	Nature of correlation not clear	FCS: 0.0365

[a] All survey questions that were significantly correlated with *L. monocytogenes* prevalence were listed with $p<0.05$;
[b] Question number corresponding to the identifiers that were defined based on the infrastructure, sanitation and management survey;
[c] Context of the significant effects based on correlation analysis ($p_{adj}<0.05$);
[d] Unadjusted p-values of each significant variables by surface types, with FCS denoted to food-contact surface, NFCS denoted to non-food-contact surface, and "Both" denoted to both surface types overall.

Table 4.2. Seven predictor variables of *L. monocytogenes* prevalence independently significant after fitted in general linear regression model by surface type ($\alpha<0.05$)

Identifier [a]	**Question** [b]	**p value** [c]
Q13_1	Do workers from bakery departments walk through the produce area during their work?	FCS: 0.0442
Q13_3	Do workers from deli departments walk through the produce area during their work?	Both: 0.0069
Q19	Are disposable gloves changed after touching non-food-contact surfaces (e.g., cart handles, hand wash sink basin, drain cover, etc.)?	FCS: 0.0204
Q38	Does water pool near misted produce case drain cover in produce retail area?	NFCS: 0.0098
Q53	How many hours a day are dedicated to cleaning tasks at the end of the day after the produce preparing area has closed?	Both: 0.0076
Q56	How often, on average, do associates change gloves?	NFCS: 0.0355
Q102	How often are food contact surfaces of produce retail case cleaned?	NFCS: 0.0014 Both: 0.0003

[a] All questions that were significantly correlated with *L. monocytogenes* prevalence were listed with $p<0.05$;
[b] Questions corresponding to the Identifiers that were defined based on the Infrastructure, Sanitation and Management Survey;
[c] p-values of each significant variables by surface types, with FCS denoted to food-contact surface, NFCS denoted to non-food-contact surface, and Both denoted to both surface types.

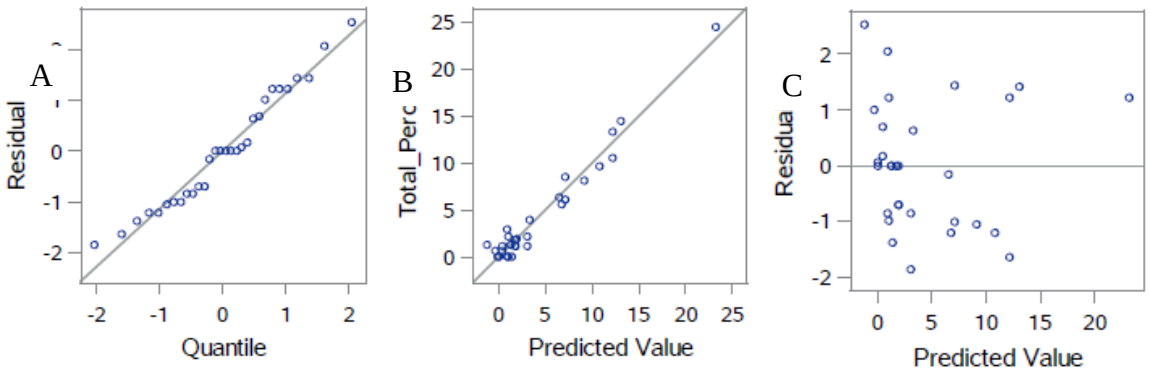

Figure 4.1. GLM (general linear model) regression fit diagnostics for *L. monocytogenes* prevalence on all surfaces (both FCS and NFCS). Panel A is a Q-Q plot of residual versus quantile; panel B compares *L. monocytogenes* prevalence to predicted value; panel C is a plot of residual versus predicted values.

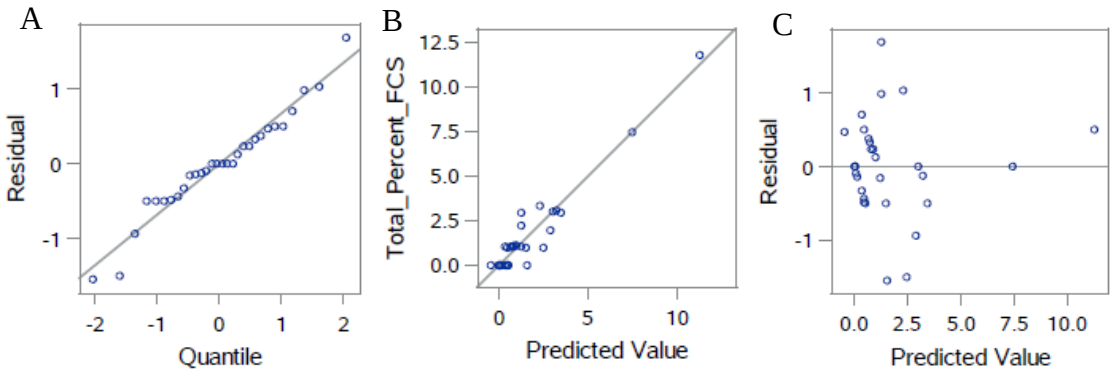

Figure 4.2. GLM (general linear model) regression fit diagnostics for *L. monocytogenes* prevalence on FCS. Panel A is a Q-Q plot of residual versus quantile; panel B compares *L. monocytogenes* prevalence to predicted value; panel C is a plot of residual versus predicted values.

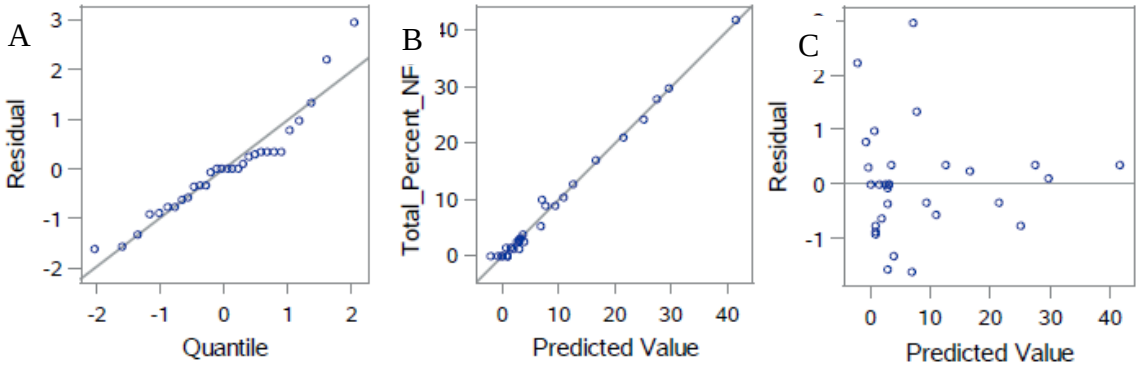

Figure 4.3. GLM (general linear model) regression fit diagnostics for *L. monocytogenes* prevalence on NFCS. Panel A is a Q-Q plot of residual versus quantile; panel B compares *L. monocytogenes* prevalence to predicted value; panel C is a plot of residual versus predicted values.

4.4.2 Changing disposable gloves after touching NFCS and having role models were associated with lower *L. monocytogenes* prevalence

We asked produce managers to report if disposable gloves were changed after touching NFCS and at what frequency. Produce managers being unaware of the status of gloves after touching NFCS correlated with high *L. monocytogenes* prevalence ($p_{adj}<0.05$ for overall, FCS, and NFCS). Regardless of surface type, two "I don't know" responses came from "high" (24.4%) and "moderate" (9.6%) prevalence stores, while 3/27 (11.1%) stores whose employees changed gloves after touching NFCS had "high" prevalence (Figure 4.4). The only store with >10% *L. monocytogenes* prevalence (11.8%) on FCS did not keep track of glove change. This store also had the highest overall and NFCS prevalence (Burnett et al., submitted). Similarly, on NFCS, the only two "I don't know" responses were both from stores with "high" prevalence, one of which had the highest prevalence (41.9%) (Burnett et al., submitted). In contrast, 7/27 (25.9%) of the stores whose employees reported changing gloves after touching NFCS had "high" prevalence on NFCS (Figure 4.5).

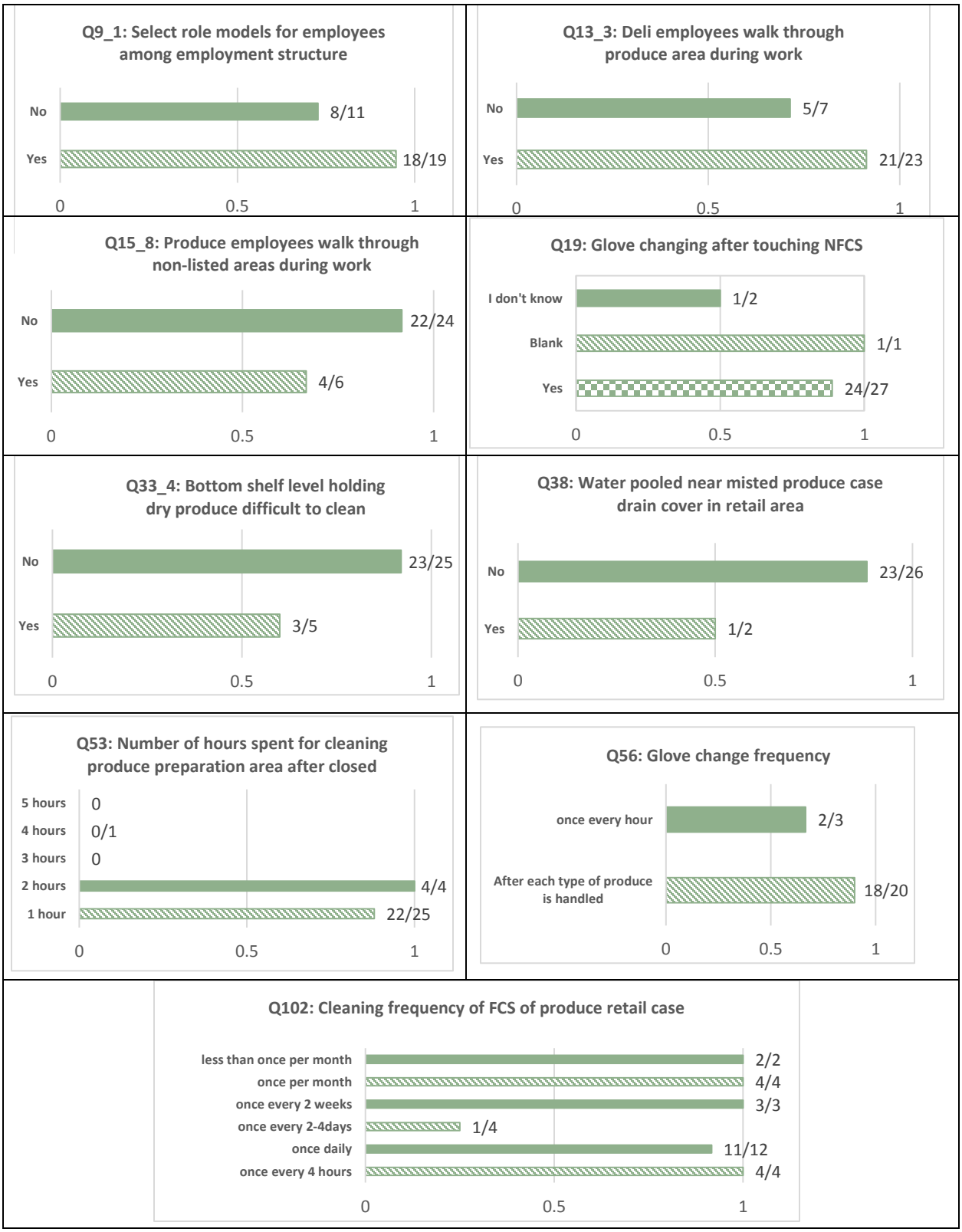

Figure 4.4. Crosstabulations of significant predictor variable ($\alpha<0.05$): bars show the portions of produce departments with <10% *L. monocytogenes* prevalence on all surfaces (both FCS and NFCS) under different responses.

Figure 4.5. Crosstabulations of significant predictor variables ($\alpha<0.05$): bars show the portions of produce departments with <10% *L. monocytogenes* prevalence on NFCS under different responses.

Changing gloves after handling different types of produce correlated significantly with reduced prevalence compared to changing once per hour ($p_{adj}<0.05$ for overall and NFCS). This survey variable was not significant for FCS. Overall, 18/20 (90%) stores that changed gloves after handling different types of produce had <10% *L. monocytogenes* prevalence, while 2/3 (66.7%) stores that changed gloves once per hour had <10% prevalence (Figure 4.4). On NFCS, all the three stores whose employees changed gloves once per hour had "high" prevalence. Their counterparts whose employees changed gloves after handling different types of produce, on the other hand, had 4/20 (20%) stores of "high" prevalence (Figure 4.5).

In the general linear regression model for *L. monocytogenes* prevalence on NFCS, "glove change frequency" remained independently significant (p=0.04). Notably, "glove status after touching NFCS" was one of the only two significant factors after fitting the regression model for prevalence on FCS (p=0.02) (Table 4.2). Probability of cross-contamination between FCS and NFCS and its entailed health hazard would be further amplified with low glove change frequency. While some stores may not use gloves, handwashing is an alternative means (Lubran et al., 2010) and should be enforced in the same manner as glove changing. Although details of proper procedures of glove changing and handwashing was not recorded in our study, it is worth noting that a standardized proper procedure is a critical and fundamental component of food safety training and management (Arendt et al., 2014). Personal hygiene has always been a key element in food safety practices (Choi et al., 2016; Griffith, Livesey, & Clayton, 2010; Lubran et al., 2010) and glove changing has been an integral component thereof, per FDA recommendation (Lubran et al, 2010; FDA, 2017). The strong correlation between glove changing and *L. monocytogenes* prevalence underscores the risk of *L. monocytogenes* transmission in produce environments via gloves and confirms the importance of changing gloves in the context of pathogen control.

4.4.3 Selecting peer role models among produce employees and controlling the number of employees working during a single shift were significantly associated with lower *L. monocytogenes* prevalence on NFCS

Our study indicated that selecting lateral peer role models in the employment structure was significantly both overall (p=0.01) and on NFCS (p=0.01), and strongly associated with reduced *L. monocytogenes* prevalence ($p_{adj}<0.05$). Regardless of surface type, a total of 18/19 (94.7%) stores with peer role model selection had <10% prevalence, while 8/11 (72.7%) stores without role

models had <10% prevalence (Figure 4.4). On NFCS, 16/19 (84.2%) produce departments that self-reported selecting peer role models among employees had "low" or "moderate" prevalence; in contrast, 5/11 (45.5%) stores without role model selection had "low" or "moderate" prevalence (Figure 4.5). Employee motivation is important in building and sustaining food safety behaviors (Jevšnik, Hlebec, & Raspor, 2008; Salazar, Ashraf, Tcheng, & Antun, 2005). From a manager's perspective, strategies to best achieve food safety outcomes include serving as a role model and reward/consequence incentivizing associates (Arendt et al., 2014; Arendt, Strohbehn, & Meyer, 2007). A study by Arendt et al. (2014) reported that food service employees described a need for role model colleagues who best understood and demonstrated food safety conducts to better motivate food safety compliance among the team. These observations suggest that employees who best follow food safety behaviors and are recognized among peers have the most potential to promote food safety compliance.

There are many strategies for implementing a role model or behavior incentivizing program in retail (Meyer, Arendt, & Strohbehn, 2011). However, the specifics of each establishment's incentive program were not recorded in the survey and thus are beyond the scope of this study. Nonetheless, having peer role models for employees in the employment structure, as identified in our study, had a greater correlation with lower *L. monocytogenes* prevalence, compared to other management methods, such as encouraging employees to ask relevant questions, encouraging employees to help each other, issuing paid or partial-paid sick leave, etc. (Appendix M). Among all options in the survey response, role model selection was the most interactive approach. It may imply that higher food safety behavior compliance positively results from a more engaged management strategy.

Multicollinearity analysis revealed that management strategy and glove changing were highly associated. Glove status after touching NFCS was highly correlated with peer role model selection among employees ($p=0.04$, Fisher's Exact Test) and the frequency of glove changing ($p=0.03$, Fisher's Exact Test). Interestingly, all 19 stores with peer role model selection reported glove changing after touching NFCS. In contrast, 8/11 (72.7%) of the stores without role model selection reported glove changing (Figure 4.6). All 20 stores that reported glove changing after touching NFCS responded with changing gloves after handling each type of produce, compared to changing hourly. Yet, in the two stores where management was unaware of glove status after touching NFCS the most frequent changing was reported to be once per hour (Figure 4.6). Echoing

our findings on glove changing from previous discussion, these results further demonstrate the fundamental role of not only hand hygiene, but a dire necessity of effective management of hand hygiene, in constructing a better food safety environment.

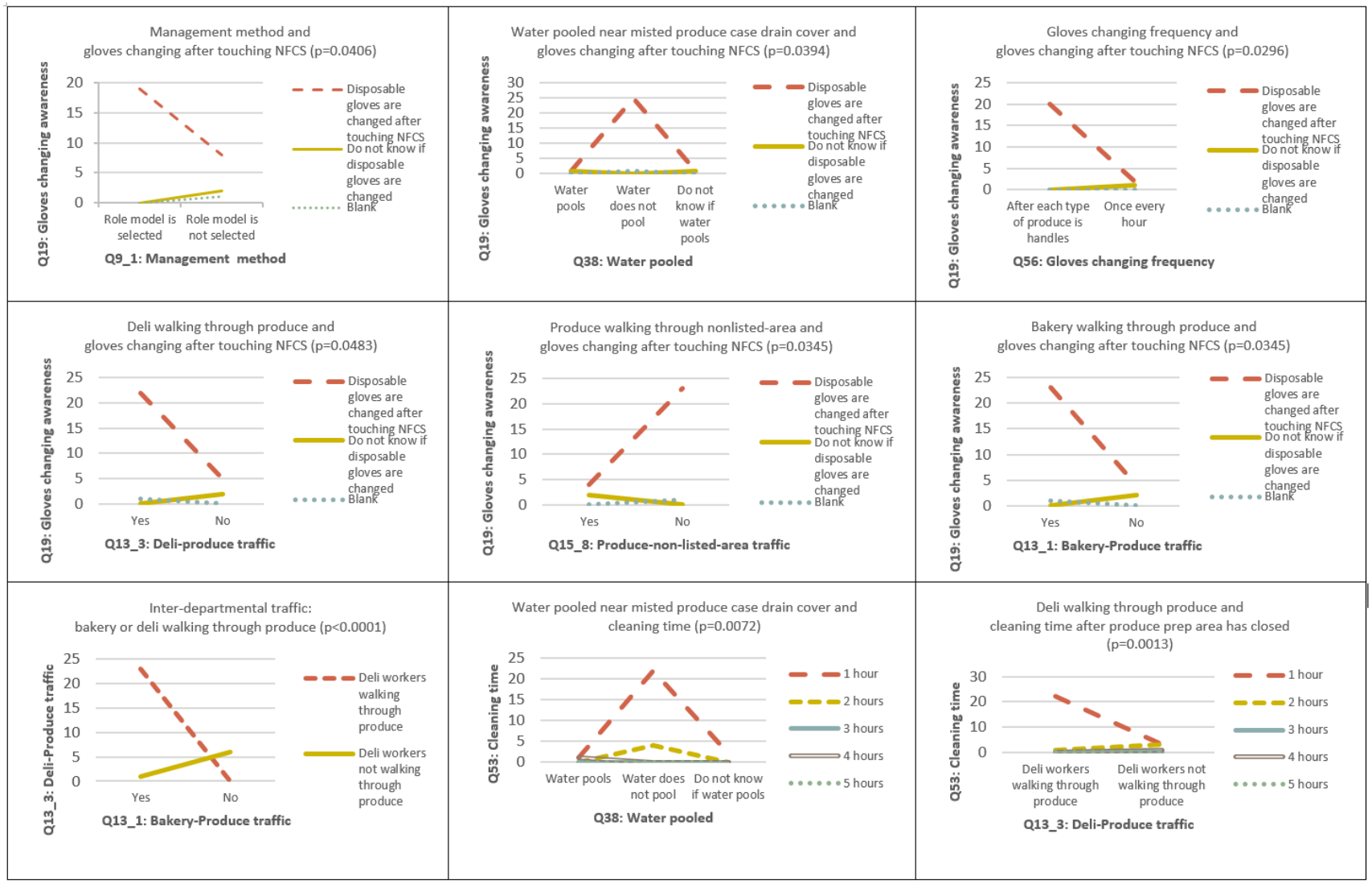

Figure 4.6. Predictor variables significantly correlated with each other by multicollinearity test ($\alpha<0.05$).

The number of employees working during one single shift in the produce area was positively correlated with *L. monocytogenes* prevalence on NFCS (p=0.04). The fraction of stores that had "low" or "moderate" prevalence followed a general decreasing trend as the number of produce employees in a single shift increased: 6/7 (85.7%) for stores choosing 1-2 employees, 10/13 (76.9%) for stores choosing 3-4 employees, 2/3 (66.7%) for stores choosing 5-6, 2/2 (100%) for stores choosing 7-8 employees, 0/3 (0%) for stores choosing 9-10 employees, and 1/2 (50%) for those choosing greater than 10 employees (Figure 4.5). Foodservice staffs' food safety behaviors and traffic flow have been shown as crucial sources for cross-contamination (U.S. Food and Drug Administration and U.S. Department of Agriculture Food Safety and Inspection Service (FDA/FSIS) 2013; FDA, 2017). Increased amount of human traffic adversely affects *L. monocytogenes* control (Queensland Government Department of Health, 2013). It is possible that the number of employees working in one shift exceeded the capacity of the food safety program, resulting in challenges for behavioral management. Hence, increased number of produce employees working in a single shift can spread *L. monocytogenes* in the environment and contribute to cross-contamination. Our data recommend that to minimize the number of employees working in the produce area is an important practice for *L. monocytogenes* control. Moreover, as the ideal sanitary facility design is unidirectional and follows the flow of production (Schmidt & Erickson, 2005), it is crucial for the produce managers to organize and station employees so as to avoid any unnecessary personnel in the produce area.

Training is crucial in establishing food safety behavior and cultivating values among employees (De Boeck et al., 2016; Green & Selman, 2005; Griffith, Livesey, & Clayton, 2010; Smigic et al., 2016). We hypothesized that the requirements to have training before employees start working would positively associate with reduced *L. monocytogenes* prevalence. Our data indicated all stores had training programs, 10% of which (3/30) offered *SuperSafeMark*® or *ServSafe*® training. There was high diversity in the employee training programs offered. Additionally, we asked about the frequency of employee retraining, the result of which was not significant. Further study is needed to explicate the relationship between employee training and *L. monocytogenes* prevalence.

4.4.4 Clean-ability of facility, absence of pooled water, and older building age significantly correlated with lower *L. monocytogenes* prevalence

Produce display cases are universally present equipment in retail grocery, necessary not only for merchandizing but also for maintaining produce shelf-life. Our data indicated that "high" prevalence stores were more likely to report having an inaccessible bottom shelf level in their dry produce display case ($p_{adj}<0.05$ for overall and NFCS), thus limiting its cleanability. Overall, 2/25 (8%) stores that reported having an accessible bottom shelf had >10% prevalence; contrarily, 2/5 (40%) stores that reported not having an accessible shelf had >10% prevalence, one of which had the highest prevalence during the concurrent environmental study (Burnett et al., submitted) (Figure 4.4). Among the 25 stores having an accessible bottom dry produce shelf, six had "high" *L. monocytogenes* prevalence on NFCS (24%). In contrast, 3/5 (60%) stores having inaccessible bottom shelves had "high" prevalence on NFCS (Figure 4.5). The result illustrates maintaining facility cleanability as a crucial approach to *L. monocytogenes* control. The cleanability of bottom dry produce shelves was strongly correlated with glove changing frequency in multicollinearity analysis (p=0.03, Fisher's Exact Test) (Figure 4.6). Among the 20 stores that reported to changing gloves after handling each type of produce, 19 (95%) found bottom dry produce shelves easy to clean. Contrarily, among the three stores that reported to changing gloves once per hour, only 1 (33.3%) responded with easy cleaning of bottom shelves. These results suggest that adequate glove management may improve cleanability of the infrastructures.

The presence of pooled water near misted produce case drain covers was also significantly associated with *L. monocytogenes* prevalence (p=0.01 for overall, p=0.001 for FCS, p=0.04 for NFCS). In all three cases, pooled water was strongly correlated with higher prevalence ($p_{adj}<0.05$). Overall, 3/26 (11.5%) stores without standing water had >10% prevalence, while 1/2 (50%) stores finding its presence had >10% prevalence (Figure 4.4). The other store reporting presence of pooled water had 5.6% overall prevalence. The only "high" FCS prevalence store reported pooled water. On NFCS, 7/26 (26.9%) stores did not have pooled water but had "high" prevalence. Yet, 1/2 (50%) stores with pooled water had >10% prevalence (Figure 4.5). Notably, the other store reporting pooled water had 8.97% *L. monocytogenes* prevalence on NFCS. After fitting a general linear model, this survey variable maintained its independent significance with p=0.01 for NFCS prevalence, and a marginal significance of p=0.05 for overall prevalence (Table 4.2). Pooled water provides a viable environment for *L. monocytogenes* growth; eliminating pooled water is essential

to controlling *L. monocytogenes* (McSwane, Linton, & Rue, 2010; Miller, 2009; FDA, 2017). Being a significant factor strongly correlated with high prevalence on all surface types, standing water facilitates can result in transmission and cross-contamination of *L. monocytogenes* in retail produce environments. Eliminating pooled water in cases is a design challenge that is complicated by capital investments required for repair.

Multicollinearity analysis showed that pooled water near misted produce case drain covers was strongly associated with glove status after touching NFCS (p=0.04). All of the 25 stores that reported glove changing after touching NFCS did not have water pooled near misted produce drain covers in retail areas, whereas the only two responses not knowing the glove status reported either pooled water present or that they were unaware of pooled water (Figure 4.6). In addition, presence of pooled water and inadequate management of glove status after touching NFCS both correlated with increased time taken for cleaning produce preparation areas ($p_{adj}<0.05$) (Figure 4.6). It is possible that limited management of hand hygiene, ineffective execution of SSOPs, and compromised infrastructure challenges can result in additional challenges such as pooled water and prolonged cleaning processes; pooled water and prolonged hours for cleaning may in turn complicate management and record keeping. These significant associations suggest that there are major challenges in efficient food safety practice management, so that the cumbersome obstacles from guidance to execution must be investigated in prospective studies to derive mechanisms of effective *L. monocytogenes* control.

We asked each manager to report the age of the facility in years. We found that older building age was marginally correlated with lower *L. monocytogenes* prevalence both overall (p=0.06) and on FCS (p=0.05). In a separate Tukey's Studentized Range Test, facilities "10-15 years old" were strongly associated with higher *L. monocytogenes* prevalence on FCS, as compared to building age "20-25 years old" ($p_{adj}<0.05$). The only store with "high" prevalence on FCS reported to be "10-15 years old". Notably, among the nine produce departments that reported "20-25 years", six had <1% *L. monocytogenes* prevalence (66.7%) on FCS – whereas none of the stores reported "10-15 years" had <1% prevalence.

Facility age and infrastructure designs vary across neighborhoods of different socioeconomic status (Droutsa, Kontoyiannidis, Dascalaki, & Balaras, 2014; Salari & Javid, 2017). Studies have shown that marginal populations of lower socioeconomic status were more prone to *L. monocytogenes* infection (Gillespie et al., 2010; Mook et al., 2010). Additionally, Arendt et al.

(2014) reported that there was strong variation in food safety behaviors and perceptions among foodservice workers of different age groups. Therefore, the strong correlation between older facilities and lower *L. monocytogenes* prevalence on FCS could be due to other socioeconomic factors, such as construction materials, average employment age, etc. Nonetheless, such association warrants further study, including a more comprehensive understanding of the role socioeconomic status and infrastructure play in *L. monocytogenes* harborage.

4.4.5 Time commitment and frequency of cleaning and sanitizing exhibited mixed association with *L. monocytogenes* prevalence

We asked survey participants to report the amount of time spent and the frequency of cleaning and sanitizing different surfaces. The FDA Food Code (2013) delineates that FCS should be cleaned every four hours and NFSC as often as necessary to prevent accumulation of soil matter. Our hypothesis was that stores adhering to cleaning and sanitation frequency stated in the FDA Food Code (2013) would have the lowest *L. monocytogenes* prevalence. However, our data indicate that relationships among frequency and time committed to cleaning and sanitizing and *L. monocytogenes* prevalence is not straightforward. For example, stores that reported cleaning and sanitizing FCS of produce retail cases "once every 2-4 days" were strongly associated with high prevalence compared with both more frequent and less frequent cleaning ($p_{adj}<0.05$ for overall and NFCS). Regardless of surface type, 11/12 (91.7%) and 4/4 (100%) stores that cleaned "once daily" or "once per 4 hours" respectively, had <10% prevalence; 1/4 (25%) stores that cleaned "once every 2-4 days" had <10% prevalence. The remaining stores with lower frequency ("once per 2 weeks", "once per month" and "less than once per month") all had "low" or "moderate" prevalence (Figure 4.4). Similarly, on NFCS, a total of 8/12 (66.7%) and 4/4 (100%) stores that cleaned FCS of produce cases "once daily" or "once per 4 hours", respectively, had <10% *L. monocytogenes* prevalence. However, 0/4 (0%) stores that cleaned "once every 2-4 days" had <10% prevalence. Counterintuitively, cleaning even less frequently ("once per 2 weeks", "once per month" and "less than once per month") was common in "low" or "moderate" prevalence stores (Figure 4.5). This factor was also independently significant in the general linear regression model for all surfaces (p=0.0003) and NFCS (p=0.001). Another unexpected finding was that longer hours committed to cleaning the produce preparation area is strongly correlated with "high" *L. monocytogenes* prevalence (p=0.004 for overall, p=0.0003 for FCS, p=0.02 for NFCS). The store reporting the

longest total time spent cleaning daily (four hours) had the highest corresponding prevalence overall, as well as on FCS and NFCS (Burnett et al., submitted). After fitting the regression model for overall prevalence, this variable was independently significant (p=0.008).

These mixed outcomes could arise from the lack of verification of cleaning and sanitizing frequencies and procedures, number of employees working, challenges due to facility designs and standing water, etc. For example, cleaner and sanitizer usage, including ft^2 applied, contact time, and water content, were shown to significantly impact bactericidal efficacy of the chemicals (West et al., 2018; West, Teska, Lineback, & Oliver., 2018; Gil & Allende, 2018). Inconsistency in procedure, management, training, and chemical use could all result in failed sanitation (Arendt et al., 2014). Additionally, SSOPs being incomplete, not comprehensible, accessible or feasible for the managers and/or employees, or improperly executed, unbeknownst to the survey respondent, are also relevant factors influencing employee performance outcome. Effective execution of standardized food safety behaviors is critical; ineffective cleaning not only takes a longer time but also could adversely spread *L. monocytogenes,* especially when the pathogen has already found its harborage point (Miller, 2009).

The time taken to clean the produce preparing area after the department has closed was significantly correlated with glove changing after touching NFCS from our subsequent multicollinearity analysis (p=0.008). Specifically, 23/27 (85.2%) stores that responded with changing gloves after touching NFCS reported a one-hour cleaning time; whereas 1/2 (50%) stores that were not aware of glove status after touching NFCS completed the cleaning tasks in one hour (Figure 4.6). The only store that did not know the glove status reported the cleaning to take four hours. These additional data suggest that cleaning efficiency may be improved by better adherence to SSOPs and emphasis of hand hygiene.

Proper cleaning tool usage is an important aspect of cleaning and sanitizing practices. Brush cleaning is recommended for routine daily cleaning, especially drain cleaning and sanitizing (FDA, 2017). We found that using scrub brushes during cleaning and sanitizing floors in the produce retail area was significant (p=0.04) and strongly associated with lower *L. monocytogenes* prevalence on NFCS ($p_{adj}<0.05$). Specifically, 11/11 (100%) stores using scrub brushes had “low” or “moderate” prevalence. Contrarily, 10/19 (52.6%) stores not using scrub brushes had “low” or “moderate” prevalence (Figure 4.5). Multicollinearity analysis further showed that using scrub brushes to clean and sanitize floors in produce retail area was strongly associated with more

frequent cleaning of produce retail cases (p=0.02, Fisher's Exact Test) (Figure 4.6). Among the 11 stores that responded that they used scrub brushes, three (27.3%) reported to clean the produce retail case "once per 4 hours" and seven (63.6%) cleaned "once daily". However, cleaning frequency of produce retail cases ranged from "once every 4 hours" to "less than once per month" in stores that did not report to use scrub brushes. Though these two questions address two different surface types (FCS and NFCS), it may suggest that increased availability of cleaning tools helps enforce cleaning and sanitizing task routines.

Similarly, mops are recommended for routine cleaning tasks (FDA, 2017). Using a mop for cleaning and sanitizing floors in the produce preparation area was significant (p=0.03) and strongly associated with lower *L. monocytogenes* prevalence on FCS ($p_{adj}<0.05$). The only "high" prevalence store did not use mops. Sanitary design and hygienical handling of cleaning tools, such as brushes, was cited as a crucial component of containing foodborne pathogen growth and sustaining food safety (Smith, 2017). While cleaning tools are useful and indispensable for proper execution of SSOPs, it is important to prevent these tools from becoming vehicles for cross-contamination; a sanitation program for cleaning tools is strongly advised.

Since bacteria transmission can occur when the cleaning tools violate hygienical design and cleaning procedures are not properly executed (Smith, 2017; FDA, 2017), the possibility of cross-contamination can be more easily contained if cleaning and sanitizing procedures are organized to follow a defined order. NFCS are major *L. monocytogenes* reservoirs compared to FCS (Hoelzer et al., 2011); saving floor cleaning for last after cleaning FCS can disrupt local microbial environments resulting in a potential source of cross-contamination (FDA/FSIS, 2013). We hypothesized that cleaning and sanitizing floors first relative to other areas in the produce preparation area correlated with lower *L. monocytogenes* prevalence. While the variable showed statistical significance for FCS (p=0.009), the nature of the effect remained undefined, warranting further study. Likewise, the frequency of cleaning and sanitizing scale surfaces (FCS) strongly related to *L. monocytogenes* prevalence on FCS (p=0.04), with the nature of effect unspecified.

4.4.6 Managing hand hygiene may be more critical than controlling inter-departmental traffic in reducing *L. monocytogenes* prevalence at retail

Cross-contamination occurs when personnel move from raw to RTE food preparation areas which jeopardizes food safety (FDA/FSIS, 2013). We asked managers if produce department

employees moved through or worked in adjacent departments, such as deli, seafood, raw meat, or other related areas. We found that produce department employees walking through departments "other" than those listed as a survey option (Appendix M) during work correlated with increased *L. monocytogenes* prevalence (p=0.04 for overall, p=0.03 for NFCS). The unlisted "other" department is a heterogenous environment, possibly a non-food-handling region such as receiving areas, offices, or "anywhere". Regardless of surface type, 22/24 (91.7%) stores without the stated inter-departmental traffic had "low" or "moderate" prevalence; 4/6 (66.7%) of their counterparts with interdepartmental traffic between produce and unlisted "other" departments had "low" or "moderate" prevalence (Figure 4.4). Looking at NFCS, among 24 stores in which produce employees did not walk through unlisted "other" departments, 18 had "low" or "moderate" prevalence (75%). In contrast, 3/6 (50%) stores with such traffic had <10% prevalence (Figure 4.5).

Counterintuitively, employees walking from delis through produce departments was associated with lower *L. monocytogenes* prevalence (p_{adj}<0.05 for overall and FCS). On all surfaces, of the total 23 stores that had employees walking from deli departments to produce, 21 had "low" or "moderate" prevalence (91.3%). However, 5 of 7 (71.4%) stores that did not identify such shared footpaths had "low" or "moderate" prevalence (Figure 4.4). The only stores with "high" *L. monocytogenes* prevalence on FCS did not report shared footpaths from deli to produce. This variable was also independently significant in the general linear regression model for overall prevalence (p=0.007) (Table 4.2). Additional questions asked about inter-departmental traffic from produce departments to delis. The same trend was observed and significant for *L. monocytogenes* prevalence on FCS (p=0.04), with produce employees walking through deli departments correlated with lower prevalence (p_{adj}<0.05). The only "high" prevalence store for FCS did not report inter-departmental employee traffic from produce to deli. The inconsistency with previous studies (Hoelzer et al., 2011; Simmons et al., 2014) may be due to enhanced cleaning and sanitizing practices in deli environments and the self-reported nature of a survey study. Incidentally, employees walking from bakery departments was also significant (p=0.01) and correlated with lower *L. monocytogenes* prevalence on FCS (p_{adj}<0.05), which remained to be significant in the general linear regression model with FCS prevalence (p=0.04).

Subsequent multicollinearity analysis revealed that inter-departmental traffic was strongly associated with glove changing. Glove status after touching NFCS was also highly associated with

produce employees walking through unlisted departments (p=0.03, Fisher's Exact Test), and inter-departmental traffic from deli through produce areas (p=0.05, Fisher's Exact Test) (Figure 4.6). Presence of inter-departmental traffic correlated with more rigorous glove management. Both stores (100%) that were unaware of glove status after touching NFCS reported absence of deli-produce traffic; in contrast, 5/27 (18.5%) of the stores that reported changing gloves after touching NFCS responded with the absence of traffic from deli to produce. Among the 23 stores that had deli-produce communication, 22 stores (95.7%) changed gloves after touching NFCS; whereas 5/7 (71.4%) of the stores that did not report such interaction changed gloves after touching NFCS (Figure 4.6). Echoing the counterintuitive results previously discussed, despite deli environments being a potentially major *L. monocytogenes* reservoir (Hoelzer et al, 2011; Simmons et al., 2014; Wang et al., 2015; Etter et al., 2017; Wu et al., submitted), it is likely that heightened attention and precaution has been emphasized on managing deli and deli-related aspects as effort to prevent *L. monocytogenes* cross-contamination. This same pattern in produce-deli traffic was also found in produce-bakery cases (p=0.03, Fisher's Exact Test). Moreover, as our data illustrate a positive correlation between the presence of deli-produce and bakery-produce interaction (p<0.0001), it can be concluded that managing hand hygiene is more critical than inter-departmental traffic, even in the high-risk departments such as delis, when considering food safety management practices at retail (Figure 4.6).

However, inter-departmental traffic from produce to unlisted "other" areas exhibited the opposite trend as correlating with glove status after touching NFCS (p=0.03, Fisher's Exact Test) to deli-produce (p=0.05, Fisher's Exact Test) and bakery-produce interactions (p=0.03, Fisher's Exact Test) (Figure 4.6). Among the six stores reporting the presence of such traffic, four (66.7%) responded positively to glove changing after touching NFCS, with the other two stores reporting "I don't know" to glove status. Contrarily, 23/24 (95.8%) stores without the traffic between produce and unlisted areas responded positively to glove changing. Indeed, complex footpath among departments is difficult to keep track of; glove changing, in this case, may not be efficiently managed. Our data confirm the necessity to enforce hand hygiene in contamination and foodborne pathogen control.

According to U.S. FDA-FSIS report on *L. monocytogenes* contamination in deli meat, retail-sliced meat is responsible for significantly more deaths associated with listeriosis annually than prepackaged meat (FSIS, 2010). A study in retail deli departments showed that proximity of

delis to the raw meat department is significantly correlated with higher *L. monocytogenes* prevalence (Wang, 2014). The presence of multiple cross-contamination routes in retail deli environments, including traffic to non-deli areas, is reportedly responsible for increased chance of *L. monocytogenes* contamination (FDA/FSIS, 2013). Our data demonstrate a mixed relationship between inter-departmental communication and *L. monocytogenes* prevalence. Yet, they confirm the risk associated with cross-contamination due to shared footpaths with unlisted areas, indicating that the floor plan of retail environments should aim to minimize inter-departmental traffic.

4.4.7 Study limitations and future directions

This is the first study examining risk factors impacting *L. monocytogenes* prevalence in retail produce handling, storage, and sales environments. Stores from diverse geographical locations throughout the U.S. and with different levels of *L. monocytogenes* prevalence were included; the survey was designed to capture permutations among stores. This study has yielded initial insights into the impact facility design, management practices, and cleaning and sanitizing frequencies have on *L. monocytogenes* prevalence in retail produce environments and will inform recommendations and interventions to improve food safety in retail produce environments. However, some produce managers indicated that the survey was too long and questions somewhat repetitive. Based on their feedback and the results, this survey will be refined for future use. Due to the scope of this study, aspects such as proper food safety procedures and post-sanitation assessment were not examined. Our mixed results are likely due to inconsistent management, chemical use, and limited sample size which all warrant further investigations. There is a need to elucidate mechanisms to evaluate, track, and verify food safety behaviors at retail in real-time. Recorded responses should be interpreted as self-reported data due to the nature of survey studies, rather than employees' actual practice. While our outcomes will serve as important indicators to direct resource distribution in bridging gaps in food safety programs, this inevitable drawback limits the scope of inference. In summary, verification is required to understand the true practice impacting *L. monocytogenes* prevalence.

4.5 Conclusions

Hand hygiene has been emphasized as a fundamental component of contamination control in foodservice environments both per FDA Food Code (2013, 2017) and according to previous studies (Lubran et al., 2010; Strohbehn, Sneed, Paez, & Meyer, 2008; Griffin, Livesey, & Clayton, 2010); our data indicate that effective management of hand hygiene is highly associated with cleanable environments, reduced time needed to clean, and diminished presence of pooled water; these factors contributed to positive food safety behavior patterns.

Our data further show that effective management and execution of proper food safety practices may be more cardinal than inter-departmental interaction for *L. monocytogenes* cross-contamination control. Water pooled near misted produce case drains in retail areas was also more likely to be absent in stores with shorter cleaning times underscoring the added value of improving infrastructure and equipment design. Successful food safety management is not measured by time taken for the cleaning or sanitizing tasks; the prolonged time may suggest challenges in practices or infrastructures unaddressed. Effective tracking and verification are crucial for food safety management and benchmarking. Taken together, we recommend management to foster environments where employees are motivated to identify themselves as important members sustaining the food safety program.

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CHAPTER 5. CONCLUSIONS

The above three studies aimed to elucidate and characterize environmental, infrastructural, and managerial risk factors on *L. monocytogenes* control at retail via longitudinal environmental sampling and concurrent food safety culture and climate survey tools. We found a significant association among food safety culture (beliefs, commitment, behaviors, trainings, etc.), infrastructure, and environmental microbial output (*L. monocytogenes* prevalence). Specifically, lower *L. monocytogenes* was correlated with more complete reported employee training program and greater sense of commitment to food safety, while deep clean can improve both employees' commitment and *L. monocytogenes* prevalence on nonfood contact surfaces. These results confirm previous study by De Boeck et al (2015), and illustrate the integral role of food safety culture in enhancing food safety status, which in our case is to reduce *L. monocytogenes* prevalence. Employees' training and sense of commitment to food safety stand among the most prominent factors; resources should be directed to build training programs that cover all that is necessary for the employees to complete their jobs, as well as to make food safety a relatable, personal experience so that food handlers value and commit to procure public health.

Although the impact of employee-executed deep cleaning on reducing *L. monocytogenes* prevalence was marginal, it was more effective than previous third-party deep cleaning (Hammons et al., 2017), indicating the employee's engagement being the foundation of a more sustainable and resilient food safety program to control foodborne pathogens such as *L. monocytogenes*. It is also possible that management incorporated aspects of food safety culture in their deep cleaning effort, to not only instruct behaviors but also emphasize relevance, which led to both the reduction of *L. monocytogenes* prevalence and the improvement of commitment to food safety.

We found a significant difference between managers and associates regarding food safety culture and climate. Specifically, associates perceived them to be more committed to food safety than their managers perceived them to be; alternatively, managers perceived themselves as having greater commitment than how their associates perceived their managers. This discrepancy between occupational positions could exhibit as an obstacle in effective execution of SSOPs, which was later confirmed in our retail produce study (Chapter 4), in which a less engaging or uninformed management was correlated with higher *L. monocytogenes* prevalence. An effective, strong food safety program, as an organization, requires the vision and knowledge to be shared among

members. While it may be difficult to have real-time communication and to keep every stakeholder informed, our results showed the importance of bridging the vertical communication gaps and flattening the hierarchy in efficient SSOPs execution and constructing a robust food safety program. In addition, poor training can escalate the hierarchy between management and employment. Indeed, as shown in the food safety culture and climate study (Chapter 3), poor and less-complete employees' training was correlated with higher *L. monocytogenes* contamination risk, indicating the possibility that ineffective management, manifested and exacerbated via employees' training program, renders the augmented hierarchy between occupational positions and as a result, a greater *L. monocytogenes* contamination risk.

Hand hygiene is among the most fundamental aspects of food safety. While it was significant in both of the above survey studies (Chapter 3 & 4), it exhibited mixed results. In the retail deli food safety culture and climate study (Chapter 3), the response to handwashing depended on the wording of the statement. Specifically, a long-term improvement in handwashing post-deep clean was observed when the survey statement was negatively phrased. When the statement was positively phrased, however, the respondents were more likely to report handwashing pre-deep clean compared to immediately after deep cleaning. In the retail produce study (Chapter 4), hand hygiene and its management were not only significant in procuring low *L. monocytogenes* prevalence, but also possibly the most fundamental factor among all tested factors, including inter-departmental traffic, SSOPs executions, and the cleanability of infrastructure. Hand hygiene has been the focal topic in food safety behavior study in the past decade; our studies confirmed its cornerstone importance in controlling *L. monocytogenes* and building food safety. The mixed results from Chapter 3 may demonstrate limitations and difficulties for the employees to properly carry out handwashing, such as time constrains and standard of proper handwashing. While it is not specified in our studies the definition of "proper handwashing", we recommend the food handlers to follow the Food Code and FDA guidance on the handwashing procedure.

In addition to the food safety culture and climate indicators that can facilitate retail businesses to evaluate their food safety programs, we developed a predictive risk model to predict *L. monocytogenes* contamination in the entire retail deli environment based on sampling five environmental sites (cold room floor, cold room racks, deli drain, trash can, scale). Our model successfully predicted 7/13 delis that had high *L. monocytogenes* prevalence. Since it is a highly conservative model, we suggest using it as a surveillance tool for routine testing. Microbial output

is an integral component of food safety culture, which both indicate the efficacy of management system and infrastructure design, as well as contribute in turn to the bettering of management system and infrastructure (De Boeck et al., 2015). This is the first study we applied this model; further validation is needed. As we observed *L. monocytogenes* prevalence and persistence in retail produce environments, a predictive risk model that is applicable for both retail deli and produce environments could also be useful.

Our studies provide critical insight to assess risks and direct resources to build a stronger, more sustainable food safety program at retail. Further validations are needed to enrich food safety culture and climate understanding in *L. monocytogenes* control as well as to evaluate the efficacy of the predictive risk model. While we relied on survey to assess food safety culture and climate, triangulation approach by incorporating additional observation and interview can yield better resolution and more holistic result. As we observed gaps in communication between retail associates and managers, approaches and tools to bridge the gaps and enable verification should be tested to facilitate industry's continuous performance.

APPENDIX A. PREDICTIVE RISK MODELS SAS CODES

```
*     *     *     *     *     Part I. 5 sites model   *     *     *     *
;
ods           pdf           file='W:\My           Documents\My           SAS
Files\5site.ExternalValidation_STW20190310.pdf';
Title 'Phase2: 5-site model (incld.13)';
Proc Logistic data=ph24new.concat24storevisit3 descending; *Running Model with
phase2 data (internal validation);
      class contam_sig  sum_lm_site16       sum_lm_site24       sum_lm_site25
sum_lm_site19 sum_lm_site13   /descending param=glm;
freq phase2; *only phase2 observations (phase2=1) will be used to estimate model
parameters;
model contam_sig  =     sum_lm_site16     sum_lm_site24          sum_lm_site25
sum_lm_site19 sum_lm_site13
/firth;
output out=ph24new.ex_val1_ph4new p=phat;
run;

data ph24new.ex_val2_ph4new; *add the high_risk variable (if phat>0.55 then
high_risk =1);
set ph24new.ex_val1_ph4new;
if phat >0.55 then high_risk =1;
else high_risk =0;
run;

Title 'Testing Cutoff 0.55; 5-site Include13'; * this step is external
validation, to assess Type I and Type II errors of the model parameter obtained
from the above internal validation;
proc freq data=ph24new.ex_val2_ph4new(where=(phase2=0)); *the 'where' code in
parentheses asks only for frequencies based on phase4 data;
tables (high_risk)*contam_sig / norow nocol;*options prevent display of column
or row percentage;
run;

ods pdf close;

*     *     *     *     *     Part II. NoDrain model  *     *     *     *
      *
;
ods           pdf           file='W:\My           Documents\My           SAS
Files\NoDrain.ExternalValidation_STW20190310.pdf';
Title 'Phase2: NoDrain Model';
Proc Logistic data=ph24new.concat24storevisit3 descending; *Running Model with
phase2 data (internal validation);
      class contam_sig  sum_lm_site16       sum_lm_site10       sum_lm_site25
sum_lm_site15 sum_lm_site19 sum_lm_site9  /descending param=glm;
freq phase2; *only phase2 observations (phase2=1) will be used to estimate model
parameters;
model contam_sig  =     sum_lm_site16       sum_lm_site10       sum_lm_site25
sum_lm_site15 sum_lm_site19 sum_lm_site9
/firth;
output out=ph24new.ex_val1_2_ph4new p=phat;
run;
```

```
data ph24new.ex_val2_2_ph4new; *add the high_risk variable (if phat>0.35 then
high_risk =1);
set ph24new.ex_val1_2_ph4new;
if phat >0.35 then high_risk =1;
else high_risk =0;
run;

Title 'Testing Cutoff 0.35; NoDrain'; * this step is external validation, to
assess Type I and Type II errors of the model parameter obtained from the above
internal validation;
proc freq data=ph24new.ex_val2_2_ph4new(where=(phase2=0)); *the 'where' code in
parentheses asks only for frequencies based on phase4 data;
tables (high_risk)*contam_sig / norow nocol;*options prevent display of column
or row percentage;
run;

ods pdf close;
```

APPENDIX B. L. MONOCYTOGENES POSITIVE SAMPLES IN BASELINE MONITORING PHASE

L. monocytogenes positive samples by site and by deli during Baseline Monitoring Phase. Thirteen delis were identified as high-risk from Screening Phase and were tested in the subsequent Baseline Monitoring Phase to confirm high-risk. *L. monocytogenes* positive samples are marked with "number of positive (number of total taken)"; blank cells are *L. monocytogenes* negative; grey cells are designated to sites not sampled.

Store	Food-contact surfaces										Non-food-contact surfaces									
	Deli case	Cold room racks	Slicer	Slicer knob	Deli case trays	3-Basin sink interior	Single basin interior	Deli case handle	Cutting board	Re-wrap table	Counter top	Deli drain	Deli area floor adjacent to drain	Deli floor	Cold room floor	Cold room drain	Trash can	Scale	Standing water	Squeege	3-Basin floor-to-wall juncture
34													1 (3)	1 (3)						1 (3)	
35											1 (3)				1 (3)	1 (3)				2 (3)	1 (3)
37							1 (3)			1 (3)		3 (3)	1 (3)			1 (3)			1 (1)	2 (3)	2 (3)
38	1 (3)		1 (3)		1 (3)	1 (3)	1 (3)			1 (3)	1 (3)						1 (3)	1 (3)			
39		1 (3)										2 (3)	2 (3)	2 (3)		3 (3)			1 (2)	3 (3)	2 (3)
40												2 (3)	1 (3)		3 (3)		1 (3)		1 (3)		
44							1 (3)					1 (3)			1 (3)					2 (3)	
47															1 (3)	1 (3)					
53									1 (3)			3 (3)	2 (3)	3 (3)	3 (3)	1 (3)			2 (3)	3 (3)	
60						1 (3)				1 (3)			1 (3)			1 (3)			1 (3)		
64															1 (3)	3 (3)				2 (3)	3 (3)
77																					
78		1 (3)													1 (3)				1 (3)		

APPENDIX C. EMPLOYEE/ASSOCIATED EXECUTED DEEP CLEAN PROTOCOL

INTRODUCTION

Purpose

The purpose of this document is to establish the initial guidelines for deep cleaning events to reduce *Listeria spp.* and *Listeria monocytogenes* in retail deli environments.

Scope

This SSOP applies to retail stores participating in the AMIF/FMIF study to reduce *L. monocytogenes* in retail delis with high *L. monocytogenes* prevalence. All equipment used to process ready-to-eat deli meats and cheeses (deli cases, slicers, cutting boards, tables) will be disassembled and cleaned. All environmental surfaces will be cleaned and sanitized.

Out of Scope: Any equipment used strictly for prepared foods or hot products (proofing cabinets, ovens, fryers, bread slicers) will be surface cleaned and sanitized--exterior only. Areas where the adjacent department is physically separate from deli areas, only the deli areas will be deep cleaned. *If the adjacent department (ex: bakery) is not distinctly separate or areas have mixed traffic flow with the deli, both departments will be included for full deep clean.*

MATERIALS

Equipment

ATP system

- (2) AccuPoint2 ATP luminometer units (Neogen Corporation)
- (150) AccuPoint2 ATP samplers (Neogen Corporation)

Cleaning Equipment (multiples appropriate for crew size)

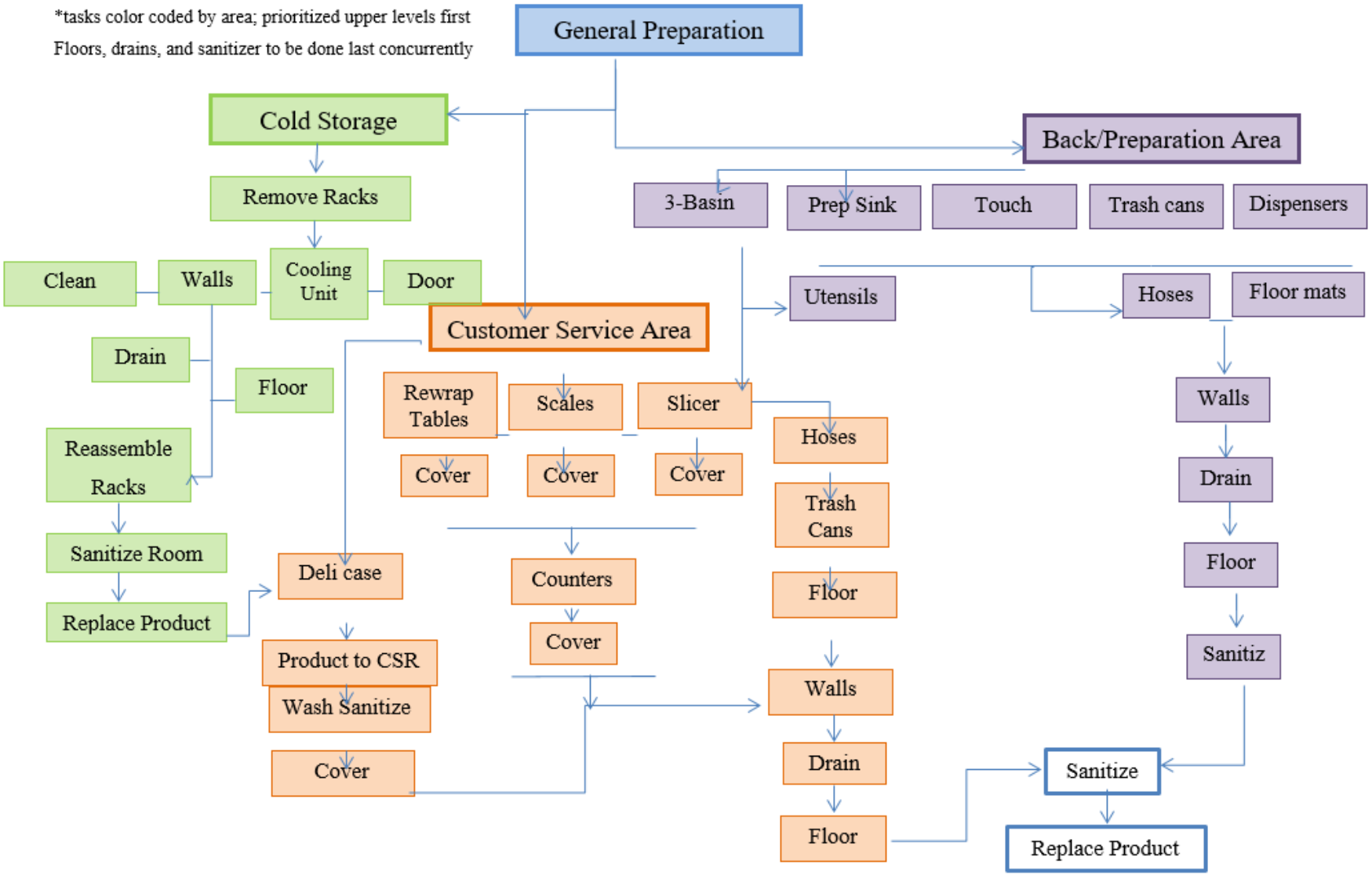
- Disposable paper towels
- (3) Short handled brushes (food contact)
- (3) Long handled brushes (food contact)
- (6) Deck brushes with long handles (walls and floors)
- (3) Rubber squeegees
- 24 Green 'scotch brite' scouring pads
- Toothbrushes or small headed scrub brush
- (15 pairs) Rubber gloves (non-latex preferred as latex is known allergen)
- Disposable gloves (drain cleaning)
- (5) 1-2 gallon buckets for water and detergent
- Spray bottles (6) each:
    - Chlorinated cleaner
    - Rinse water
    - Sanitizer
- (4) Flat blade scrapers (for removing caulk, adhesive, other grime)
- Tool kit (screw drivers, allen wrenches, misc. needs)
- Terry cloth towel for foot baths/dip stations
- (2) shallow plastic totes for foot baths/dip stations
- (1) large, deep plastic tote for equipment sanitizer bath
- New hose (50-100ft, appropriate for department size)
    - Extra hose for deep clean execution
    - A y-split is recommended if only 1 water spigot in the department
- (2 pair) Cut-resistant gloves
- Typhoon or other large floor water management system
- Shop vacuum (wet/dry) for deli case cleaning

(As needed items)

- Waterproof pants for crew (rain slicker bottoms)
- Hairnets or hats for all crew
- New low pressure hose nozzle
- Zorba water absorbing dam for entry ways
- Colored magnets to mark cleaned tables

Chemicals- *Source to be determined by retailer sanitation/food safety personnel*

- Chlorinated cleaner approved for food contact and non-food contact surfaces
- Degreasing agent (approved FCS and NFCS)
- Block whitener (2-3 gallons)
- Quaternary ammonia based sanitizer at disinfectant concentrations (450ppm)
- Foaming drain cleaner (if available)
- Mobile dispensing cart (or other hose dispensing system)


*tasks color coded by area; prioritized upper levels first
Floors, drains, and sanitizer to be done last concurrently
General Preparation
Cold Storage
Remove Racks
Clean
Walls
Cooling Unit
Door
Drain
Floor
Reassemble Racks
Sanitize Room
Replace Product
Back/Preparation Area
3-Basin
Prep Sink
Touch
Trash cans
Dispensers
Utensils
Hoses
Floor mats
Walls
Drain
Floor
Sanitiz
Customer Service Area
Rewrap Tables
Scales
Slicer
Cover
Cover
Cover
Hoses
Trash Cans
Floor
Walls
Drain
Floor
Deli case
Product to CSR
Wash Sanitize
Cover
Counters
Cover
Sanitize
Replace Product

PROCEDURES

Retailer/Store will:

1. Comprehensively communicate deep cleaning plan throughout management chain (corporate VP's to regional directors to store managers to deli associates).
2. Schedule extra labor hours are required to complete store tasks before, during, and after clean:
    a. Web-based training session for leadership team, at least one week before deep clean
    b. Training sessions at each store for all personnel participating in the deep clean the day before cleaning begins (including store manager, deli manager, and deli associates)
    c. Labor to remove excess clutter from deli before deep clean
    d. Maintenance assistance during deep clean for equipment handling (deli case, slicers, cooling units, breakers/lights).
    e. Time and labor to support 12 hour shut down period; 2 shifts of 10 persons for cleaning, 8 hours per shift with 4 hours of overlap (both shifts on duty)
    f. Increased time allocation for daily cleaning post deep cleans as needed.
3. Communicate special requisitions for cleaning implements (hoses, squeegees, brushes) needed during and after the deep clean.
    a. Cleaning tools- New cleaning tools should be used for the deep clean and left freshly sanitized for store use after completion.
        i. *If foam squeegees are used during the deep clean event, they will NOT be left in the deli. Only hard, sanitizable plastic squeegees will be left for regular deli use.*
    b. Chemicals-Follow protocol recommendations for active ingredients, (source: retailer supplier)
    c. Equipment-
        i. wet/dry vacuum is essential for water management of heavily soiled deli cases,
        ii. alternative floor water management system (ex: Typhoon) is recommended for managing water on poorly sloped floors or areas without sufficient floor drains
    d. Personal Protective Equipment for all participating personnel (smocks/aprons, rubber boots, gloves, & eye goggles)
4. Plan to maintain appropriate cold chain for all food products
    a. All products must be removed from the department and placed in an appropriate ready-to-eat products cooler (ie. Produce, or designated refrigerated truck).

Purdue team will:

1. Collaborate and communicate with retailer to schedule deep clean 3 weeks in advance.
2. Develop a detailed cleaning plan. Including:
    a. Individual assignment of tasks
    b. Estimated timeline for each set of tasks through cleaning event
    c. Planned rest breaks & tracking of cleaning milestones
3. Acquire supplies for validation and verification of cleaning
    a. ATP samplers and luminometer for rapid validation
    b. Environmental sampling sponges
    c. Labor and supplies for detection of *L. monocytogenes* from environmental samples
    d. Fingerprinting of *L. monocytogenes* isolates by Pulsed Field Gel Electrophoresis (PFGE)
4. Support travel costs of Purdue staff to each deep clean

Preparation

To be completed immediately before the deep clean process will be conducted.

1. **Set-up break room/homeroom –**Store Team

    Designate a room for the cleaning crew to leave personal items, take breaks, and conduct team meetings during the deep clean.

2. **Baseline Sample Collection-** Purdue team

    Swab for ATP and LM concurrently pre-deep clean using 20 standard sites from Pre-Intervention

    a. NOTE: ATP sample should be collected before the LM swab to prevent the neutralizing buffer form affecting the ATP system.

3. **Chemical calibration-** Corporate leadership in collaboration with store staff
    a. Calibrate detergent and sanitizer dispensers for each three-basin sink, mobile cart, wall foaming units, and other dispensing units to be used for the deep clean.
    b. Prepare boot dip station with sanitizer (450ppm) and a towel on the exit into the store area to absorb excess sanitizer and water (minimize moisture tracked onto store floor).
        i. Dip station should be check every few hours and sanitizer changed as needed to maintain active concentration

4. Cleaning team meeting- led by Purdue Team

Review cleaning plan, individual assignments, & distribute PPE

a. Smocks, gloves, rubber boots, and eye goggles, as needed.

b. Designate and label scrub brushes for Drain, Floors, and Walls with permanent marker

c. Divide crew into 4 teams: 1) CSR/Prep-Area Crew; 2) Deli cases, slicers, Food contact surfaces; 3) Small utensils/Sink-Crew; 4) Drains, floor-wall junctures, other priority tasks.

Maintenance Tasks

If tasks completed immediately after swab collection, the cleaning processes will be accelerated. Tasks may be executed concurrent with cleaning as needed.

1) Shutdown refrigeration and fans in cold storage room and deli cases
    a) Clear or cancel alarms from refrigeration units
2) Disassemble deli case (Remove fan blades, motors, and cover from coils)
    a) If fan motors cannot be removed, wipe down by hand and cover with plastic bags fastened with a rubber band to protect motors from water damage
3) Remove fan covers and blades from condenser unit in cold storage room
4) Remove kick-plates from along deli case bottoms to improve water management ability and clear debris behind kick-plate
    a) Note: Team will need to assess if kick-plate is best left off during the scrub down to facilitate water management, or if plate should be replaced to protect any exposed electrical components
5) Tape over electrical outlets on walls to prevent water damage during scrub down
6) Be available during cleaning for random tasks as needed
    a) Be prepared to address any drain issues, in deli case, cold storage room, or regular floor drains. CO2 tanks to "punch" the drains have been useful in the past.
    b) If drains have not be cleared by a plumber in advance of cleaning, be prepared to call a plumber at night.
7) *****As cleaning is completed****
8) Reassemble deli case (fans, motors, and other components)
9) Turn on refrigeration to deli case when cleared by Purdue staff (after interior sanitized)
    a) Confirm correct temperature
    b) Confirm function of alarms
10) Reassemble cold storage room fans and covers
11) Turn on refrigeration to cold storage room when cleared (after interior is sanitized)
    a) Confirm correct temperature
    b) Confirm function of alarms

Cleaning Actions

Shift One-- Deli shutdown and emptying (2-3 hours)

All Teams

Start early, plan breaks with refreshments for all crew members. Leadership team should monitor crew member fatigue closely.

All cleaning crew members must wash hands before entering the deli (restroom, break room or other available sink).

1. Wash with soap and warm water to scrub hands, between fingers, under fingernails for 20 seconds (sing Happy Birthday song twice)
2. Use a clean paper towel to dry hands and turn off faucet
3. Use paper towel to handle door knobs when exiting the restroom.

Cleaning Equipment/Tools

1. New cleaning tools must be labeled (FCS/NFCS), washed and rinsed, then:
2. Sanitize by soaking for 15min at minimum of 450ppm
    a. Check sanitizer concentration after 5 and 10 min, change sanitizer solution as needed to ensure proper concentration
    b. Sanitizer solution should not become soiled, if so, repeat the wash and rinse steps until solution remains clear.
3. Cleaning tools not should be stored in sanitizer solution when not in use
4. FCS cleaning tools placed on floors should immediately be re-sanitized

Teams 1, 2 & 3

Wash, Rinse, Sanitize carts for removal of food products

4. Work near a functioning floor drain
5. Thoroughly scrub frame and wheels of cart and then rinse thoroughly to remove all detergent and soils, using large hose and NFCS scrubbing pads
6. Thoroughly scrub the food contact surfaces and cart handle with detergent. Rinse using the disposable cleaning cloth from rinse bucket to remove detergent and soils.
7. Sanitize using the cleaning cloth from the sanitizer bucket or the spray bottle.
8. Allow the surfaces to air dry.
9. Wash hands at dedicated hand sink.

Team 4

Prepare hand washing sink areas

1. Scrub interior and exterior of hand sink and contact points using a chlorinated cleaner

a. Special attention to corners inside sink, exterior edge, faucet, handles and drain.
b. Touch points include soap dispensers, towel dispensers,

2. Rinse and test touch points for ATP signal (if fails, repeat cleaning)
   a. Once ATP passes (<150 RLU) sanitize (450ppm)

---*The following are general assignments for each team. Adjustments to be made for the layout of each deli, but generally to be executed sequentially* ----

Team One

3. Removal of food products from Cold Storage Room
   a. Wash hands and put on new food service gloves.
   b. Wipe unopened, intact packages with a clean sanitizer-soaked towel.
      i. Change towels and sanitizer solution frequently. Ensure 200 ppm concentration
      ii. DO NOT immerse food packages in sanitizer solution
   c. Remove all product from CSR, placing on a clean and sanitized shopping cart or rack and place under proper refrigeration to maintain the cold chain.
      i. Label each tray/rack with product place of origin
   d. Discard food in opened or damaged packages and all prepared foods in the department to be cleaned

Team Two

4. Removal of deli meat and cheese products from deli cases
   a. Wash hands and put on new food service gloves.
   b. Pull product from shelves and well preferably in 4ft sections. Product is to be placed on sanitized trays on and mobile racks. Each cart/rack is to be marked which 4ft section of origin. The tag strips from the 4ft section are labeled, removed, bundled up and placed in carts.
      i. Discard food in opened or damaged packages and all prepared foods in the department to be cleaned
      ii. Wipe unopened, intact packages with a clean sanitizer-soaked towel. Change towels and sanitizer solution frequently. Ensure 200 ppm Quat concentration in the towel buckets.
      iii. DO NOT immerse food packages in sanitizer solution
      iv. Work quickly to place carts under proper refrigeration to maintain the cold chain.
   c. Request maintenance personnel shutdown deli case cooling systems to allow equipment to warm to room temperature.

Team Three

5. Removal of prepare foods and salads
    a. Wash hands and put on new food service gloves.
    b. All open salads and prepared foods must be discarded
        i. Empty trays should be rinsed and stacked near 3-basin sink
    c. Wipe unopened, intact packages with a clean sanitizer-soaked towel.
        i. Change towels and sanitizer solution frequently. Ensure 200 ppm Quat concentration in the towel buckets.
        ii. DO NOT immerse food packages in sanitizer solution
        iii. Work quickly to place carts under proper refrigeration to maintain the cold chain.

-As a great deal of dishes and small food contact surfaces will need to be cleaned, TEAM 3 should immediately proceed to preparing the 3-basin sink

6. Three (3) Basin sinks
    a. Empty sink
    b. Scrub interior and exterior by hand using a degreasing agent and chlorinated cleaner
    c. Special attention to corners inside sink, underside of exterior edge, faucet and drain
    d. Scrub drain
    e. Scrub underside of sink, legs, and support bars
        i. Green scouring pads, flat bladed scraper, chlorinated cleaner, and degreasing detergent are recommended
        ii. *Hint: Kneeling on a plastic sheet or tote lid can be helpful to reach corners
    f. Rinse and test for ATP (if fails, repeat cleaning)
    g. Once ATP passes (<150 RLU) sanitize (450ppm)

Team Four *Remove everything else*

7. Remove SCALES and other sensitive electronics
    a. Scales will be cleaned by designated team members and returned to deli after major environmental surfaces have been washed, rinsed, and sanitized to reduce risk of water damage.
8. Removal of paperwork and dry goods
    a. Deli manager and should supervise removal of paperwork to designated dry location outside of deep cleaning zone
    b. Dry goods (paper towels, napkins, plastic serving containers) packaged and moved to a dry location outside of deep cleaning zone.

9. Removal of miscellaneous items
    a. Includes removal of clutter from underneath sinks, in closets, near walls, and throughout the deli and adjacent prepared foods area, if applicable.
    b. A manager or regional manager (or corporate representative) should be available to make inventory decisions (e.g., if clutter may be discarded or stored elsewhere).

If it cannot get wet, it should not remain in the deli.

Targeted Environmental cleaning *(4-5 hours; 2nd half of first shift)*

Team 1- Preparation Area

Cold Storage Room (CSR)

---Should be open and warming after store team shutoff refrigeration unit previously--

1. Sweep CSR floor to remove large debris.
2. Spray whole room and racks with chlorinated cleaner.
3. Racks→If space allows, scrub racks inside deli cooler.
    a. Otherwise remove racks—pre-scrape with blade to remove grime as needed.
    b. Scrub with chlorinated cleaner using hand brushes and scrub pads
    c. Rinse, test for ATP response until pass (<150 RLU passes)
4. Cooling unit
    a. Scrub exterior surface of unit; special attention to tight corners and niches.
    b. Rinse thoroughly
5. Walls
    a. Scrub using WALL o-deck brush to remove soil using degreasing detergent and rinse.
6. Door gasket
    a. Scrub gasket with degreasing detergent (allow soak time for set on grime)
    b. Rinse and sanitize door gasket with spray bottles or hose (450ppm sanitizer).
7. Door Interior
    a. Wash and rinse door interior and exterior using a degreasing agent if needed
    b. Pay special attention to crevices and seams.
    c. As needed→Scrub plastic curtain with detergent (both sides) and rinse.
8. Floor
    a. Apply foaming detergent to floor and walls just above the floor wall junctures.
    b. Vigorously brush the foaming detergent on floor surfaces, floor/wall juncture, under equipment, and all other areas within cold storage room. (FLOOR deck brush)
9. Rinse condenser, walls, and floors of CSR until all evidence of foam is removed.
    a. Squeegee excess water toward drains.
10. Test ATP response on each surface (condenser, walls, corners, floor, drain, other)
    a. Re-clean and retest until each surface passes ATP threshold.
11. Sanitize (450ppm) whole CSR from top to bottom using hose dispenser.
    a. Allow to air dry, do NOT squeegee sanitizer to drain.

Rear Preparation Area

-if time allows, Team 1 should begin cleaning food prep tables, racks and shelves

1. Tables, Work Surfaces, Racks, and Shelves
    a. Fill buckets / spray bottles with detergent solution, rinse water, and sanitizer. Use separate disposable cleaning cloths for each.

b. Flip tables on side to thoroughly scrub bottom, legs, back, and edges of each.
c. Scrub ALL table surfaces with detergent solution.
d. Rinse to remove all detergent and soils.
e. Flip table upright, scrub interior of each shelf, wall, and surface
f. Rinse thoroughly (check bottom shelf for debris)
g. Test for ATP response; re-clean until ATP passes
h. Mark each clean table with designated magnet

Team 2- Customer Service Area

Deli case

Follow the suggested manufacturers cleaning procedures for use of cleaning and sanitizing chemicals.

1. Maintenance personnel should shutoff cooling system and fans in all deli cases
2. Remove deli case doors, trays, shelves, and dividers layer by layer.
    a. Set all components aside on designated table or counter; to be cleaned during 2nd shift
3. Use a wet-dry vacuum to remove large debris during disassembly
    a. Minimize debris which may clog the deli case drain by wet vac or
4. After debris removal from well, flush out the drain using a hot water hose, it may be necessary to use a snake to remove any blockage.
5. Use chlorinated cleaner and scouring pads to clean interior of deli case and coils
6. Rinse thoroughly with copious hot water
7. Swab for ATP in several locations (approximately 1 per 4 foot section)
    a. If ATP fails (>150 RLU), repeat cleaning until ATP passes
8. After a Team Leader approves cleanliness, towels are used to remove excess water from panels, shelves and well.
9. Sanitize deli case base unit interior

Environmental Surfaces

1. Walls
    a. Move racks and equipment away from walls
    b. Scrub with brushes and detergent (WALL brushes only)
    c. Rinse with low pressure hose
    d. Test for ATP response (1 per 8 foot section of wall)
    e. Sanitize (450ppm)
    f. Return racks and equipment

2. Touch points (light switches, telephones, door handles)
    a. Wipe down the touch points and surrounding area with detergent solution.
    b. Rinse with cleaning cloth from rinse bucket to remove all detergent and soils.
    c. Test for ATP response, re-clean until ATP passes.
    d. Sanitize by using the cleaning cloth from the sanitizer bucket or spray bottle.

e. Allow to air dry.

3. Floor
    a. Apply foaming detergent to floor using hot water.
    b. Vigorously brush the foaming detergent on floor surfaces, floor/wall juncture, under equipment, and all other areas within cold storage room. (FLOOR deck brush)
    c. Rinse all washed areas with low pressure/volume water until all evidence of foam is removed.
    d. Squeegee excess water toward drains.
    e. Avoid splashing of all chemicals and water.

-If time allows, begin cleaning major grime from tables, racks, and shelves--

4. Tables, Work Surfaces, Racks, and Shelves
    a. Fill buckets / spray bottles with detergent solution, rinse water, and sanitizer. Use separate disposable cleaning cloths for each.
    b. Flip tables on side to thoroughly scrub bottom, legs, back, and edges of each.
    c. Scrub ALL table surfaces with detergent solution.
    d. Rinse to remove all detergent and soils.
    e. Flip table upright, scrub interior of each shelf, wall, and surface
    f. Rinse thoroughly (check bottom shelf and corners for debris)
    g. Test for ATP response; re-clean until ATP passes (<150 RLU)
    h. Mark each clean table with designated colored magnet

Team 3- Sink Crew

--*Clean all small pieces of equipment.* Prioritized order: salad bowls, trays, utensils, deli case parts, cutting boards, slicer components, rewrap table components, and other miscellaneous items.

1. Follow general procedure below:
    a. Pre-scrape grime, scrub, wash, and rinse utilizing the 3 compartment sink used to clean food contact equipment and utensils
    b. Test for ATP response after rinsing, re-clean and retest until ATP passes (<150 RLU)
        i. Not every item cleaned may be tested for ATP, in general the first of each class of item should be test (ex: first deli case door) and every third piece after that depending on quantity and success of cleaning. Frequency of testing to be determined by Purdue staff.
    c. Sanitize at 450ppm
    d. Allow to air dry in designated space
    e. Return to appropriate area of deli for reassembly as required

Team 4- Priority tasks

1. Drying Racks and Shelves
   Clean 1-2 shelves near 3-basin sink for equipment Team 3 has cleaned and sanitized
   a. Fill buckets / spray bottles with detergent solution, rinse water, and sanitizer. Use separate disposable cleaning cloths for each.
   b. Flip racks on side to thoroughly scrub bottom, legs, back, and edges of each.
   c. Scrub ALL surfaces with detergent solution.
   d. Rinse to remove all detergent and soils.
   e. Flip rack upright, scrub interior of each shelf, wall, and surface
   f. Rinse thoroughly (check bottom shelf for debris)
   g. Test for ATP response; re-clean until ATP passes
   h. Mark each clean rack with designated magnet

2. Cutting boards
   a. Rinse debris from cutting board surfaces
   b. Place cutting boards on stainless steel surface (Alternative: 2 sets of turned over plastic milk crates create a sturdy table area)
      i. Do NOT place cutting boards on aluminum or soft-metal surfaces; block whitener will damage these materials
   c. Use a fresh nylon scrub brush, apply block whitener (bleach paste) to all surfaces of cutting board using a soft circular motion.
      i. Take care not to spatter block whitener on clothing, soft metals or other material which would be damaged by contact with this strong chemical.
   d. Allow block whitener to soak cutting boards
      i. Shift 2 will rinse, then wash-rinse-sanitize cutting boards in 3-basin sink
      ii. Up to 10 hours is acceptable contact time for plastic cutting boards

3. Floor Drains (throughout deli, including CSR)
   a. Follow the label directions for all cleaning/sanitizing chemicals and use appropriate PPE.
   b. Place disposable gloves on both hands and remove drain cover along with the basket and discard any debris in the basket as well as any debris in the drain.
   c. Place drain cover and basket into bucket of chlorinated cleaning solution. Allow to pre-soak per manufacturer's instructions.
   d. Scrub drain components inside bucket of solution using scouring pad.
      i. Do NOT use drain brush; this will minimize spatter and risk of cross contamination out of the drain into the department
   e. Apply designated drain cleaner or chlorinated cleaner directly to drain and allow contact time per manufacturer's instructions (at least 3-5 minutes).
   f. Scrub drain using scouring pad.
      i. Do NOT use drain brush; this will minimize spatter and risk of cross contamination out of the drain into the department

ii. Note: It is NOT recommended to scrub into the drain/sewer line below the base of sink basin.

g. Replace drain basket and cover, if provided.
h. Remove and discard disposable gloves and scouring pads.
i. Wash hands thoroughly.
j. If drain or any component is composed of white PVC pipe:
    i. remove debris by scrubbing as described above
    ii. Cover in block whitener paste; allow to soak for at least 30 minutes
    iii. Rinse block whitener; reapply and allow longer soak time as needed
k. Rinse the drain cover, basket and drain with a low pressure hot water.
l. Sanitize drain cover, basket and drain (450ppm Quat)
m. Note: drain will be sanitized again concurrently with the room
n. Thoroughly clean and sanitize the bucket used for cleaning drain cover and basket at store's mop sink/janitor's area.

Note: In cases where drain covers cannot be removed safely, apply the "Specialized Drain Cleaning Foam" or soak with block whitener paste as best as possible.

4. Floor-to-wall juncture under each sink
    a. Clean as described above for general floor, scrub thoroughly
    b. Add block whitener to fiber-reinforced-plastic (FRP) walls under sinks, and in FTW juncture.
    c. Allow block whitener to soak for at least 30 min.
    d. Rinse thoroughly with water to remove.
    e. Repeat procedure above at least twice (more repetitions as needed)

5. Floor mats
    a. Remove from floor and take to designated cleaning area
    b. Scrub with degreasing detergent and brushes to remove soils
    c. Rinse to remove detergent and soils
    d. Test for ATP response until passes
    e. Apply sanitizer 450ppm, special attention to crevasses and niches. Allow to air dry
    f. Do not replace on floors until both the mat and the deli floor have been sanitized and allowed to air dry.

6. Trash cans
    a. Scrub trash can exterior and interior with chlorinated cleaner solution, using a NFCS nylon brush. Special attention to the handles, corners and areas with built up soils.
    b. Soak interior of trashcan with detergent as needed.
    c. Rinse to remove all detergent and soils.
    d. Test ATP response, re-clean until ATP passes.

e. Sanitize (450ppm)
f. Allow to air dry inverted in designated area, NOT on deli floors

--if time allows: Assist teams 1 & 2 in scrubbing walls and floors, then tables, racks, and mobile carts—

***End of Shift*:** All team members except 3 vacate department. Remaining team will sanitize walls, floors, tables, sinks, and all water durable surfaces in deli, including Cold Storage Room. Team meeting with Shift 2 counterparts to explain current progress and next steps.

Shift TWO

1) 20 min meeting with first shift teams to define tasks completed and next steps
2) ***Complete any tasks left unfinished by Shift One***
3) Begin tasks outlined below

Food Contact Surfaces and Finish Cleaning (4-5 hours)

Team 1

Deli case components

1. Move deli case components to CSR for cleaning: Priority→bottom shelves, shelf liner pieces, display risers, deli case doors, and trays
2. Scrub each piece with chlorinated cleaner, scouring pads, and FCS brushes
    a. Special attention to corners and tight niches
3. Rinse each piece thoroughly
4. Test for ATP Response; re-clean until ATP passes (<150 RLU)
5. Sanitize each piece inside CSR
6. Cleaned and sanitized components should be replaced inside cleaned and sanitized deli case.
    a. If deli case base unit did not pass ATP test before shift change, Team 1 will assist Team 2 to clean base of deli case and achieve passing ATP scores before reassembly.
7. Replace deli case components in appropriate positions
8. Re-sanitize deli case interior and exterior after reassembly is complete using spray bottles or available hose system (450ppm).

Mobile Carts/Racks

--Carts may be moved to CSR and cleaned inside as space allows--

1. Flip cart on side to scrub wheels and underside of cart frame with detergent using scouring pad or NFCS brush
2. Rinse.
3. Thoroughly scrub the food contact surfaces and cart handle with detergent using fresh scouring pad and FCS brush.
4. Rinse to remove detergent and soils.
5. Test for ATP response, re-clean until surface passes.
6. Mark cleaned and sanitized carts with designated magnet

Cold Storage Room

1. Apply chlorinated cleaner to whole CSR
2. Scrub walls and racks using a WALL brush
3. Scrub floors and floor to wall juncture using FLOOR brush
4. ***Request TEAM 4 to clean CSR drain one last time, as needed***
5. Rinse thoroughly to remove all foam
6. Squeegee excess water to drain
7. Sanitize whole room, including drain (450ppm)
8. Request maintenance personnel turn on CSR cooling unit and confirm proper function

Assist other teams as needed for remainder of shift.

<u>Team 2</u>- Food Contact Surfaces
Deli Slicer(s)

1. Turn power off
2. Disconnect the plug from the power source
3. Make sure the index knob is turned to the right past 'zero' until it stops
4. Select 'cut resistant gloves that fits your hands and place them on both hands when cleaning the slicer
5. Cover 'cut resistant' gloves with disposable gloves
6. Disassemble the slicer according to the manufacturer's instructions (remove carriage tray, food pusher, blade guard, etc.)
7. Pre-scrape areas of slicer to remove food debris
8. Removable slicer parts are to be washed, rinsed and sanitized at 3-compartment sink
9. Scrub to remove soil and debris with a nylon brush or scouring pad as needed.
10. Sanitize (450ppm) and allow to air dry.
11. Wash, rinse and sanitize stationary parts of slicer (blade, tray area, bottom, etc.)
12. **Be careful not to damage electric motor or control panel with water**
13. Scrub stationary parts and area under the slicer with a nylon brush,
14. Note: Clean both sides of the slicer blade with cloth, non-abrasive pad or brush. Always wipe from the center of the blade toward the outer edge (towards you). Move the blade manually to get the full edge
15. Wash with detergent and a cleaning cloth
16. Rinse with fresh clean water
17. Test for ATP response, re-clean until ATP <150 RLU
18. Sanitize with a cleaning cloth or spray bottle (450ppm)
19. Allow at least 2 min contact time for sanitizer to work
20. Wash hands and put on disposable gloves
21. Reassemble slicer in a sanitary manner so as not to contaminate the equipment
22. Re-sanitize assembled slicer using hand spray bottle of sanitizer solution
23. Cover slicer with clean plastic bag to reduce risk of cross contamination during remaining cleaning

Rewrap tables

1. Unplug/disconnect from electric power source
2. Be careful not to damage electric controls or other pieces with water during cleaning
3. Wipe down the body, top, and other touch points of each rewrap table with detergent solution.
4. Rinse with cleaning cloth from rinse bucket to remove all detergent and soils.
5. Test ATP response, re-clean until ATP <150RLU
6. Sanitize (450ppm) by using the cleaning cloth from the sanitizer bucket or spray bottle on surfaces that were cleaned and rinsed.
7. Cover with protective plastic to minimize cross contamination. Allow to air dry.

Food Preparation Sink (1-basin) and Hand Washing Sinks

1. Empty sink compartments, remove any food scraps and discard.
2. Use detergent to scrub all backsplash(s), strainer(s), interior surfaces/compartment(s), drain board(s), faucet(s), handle(s) and knob(s).
3. Use detergent to clean the drain basket and stopper mechanism
4. If applicable, use detergent and sanitizer to clean and sanitize any rack(s) used to hold product while it's being opened.
5. Scrub underside of sink, legs, and support bars
    a. Green scouring pads, flat bladed scraper, chlorinated cleaner, and degreasing detergent are recommended
    b. *Hint: Kneeling on a plastic sheet or tote lid can be helpful to reach corners
6. Rinse all surfaces
7. Test for ATP response
a. Re-clean and retest until all surfaces pass ATP thresholds
8. Allow surfaces to air dry prior to next use.

Tables, Work Surfaces, Racks, and Shelves

1. Fill buckets / spray bottles with detergent solution, rinse water, and sanitizer. Use separate disposable cleaning cloths for each.
2. Flip tables on side to thoroughly scrub bottom, legs, back, and edges of each.
3. Scrub ALL table surfaces with detergent solution.
4. Rinse to remove all detergent and soils.
5. Flip table upright, scrub interior of each shelf, wall, and surface
6. Rinse thoroughly (check bottom shelf for debris)
7. Test for ATP response; re-clean until ATP passes
8. Mark each clean table with designated magnet

Mobile Carts

1. Flip cart on side to scrub wheels and underside of cart frame with detergent.
2. Rinse.
3. Thoroughly scrub the food contact surfaces and cart handle with detergent.
4. Rinse to remove detergent and soils.
5. Test for ATP response, re-clean until surface passes.
6. Mark cleaned and sanitized carts with designated magnet

Team 3- Sink Crew

--*Clean all small pieces of equipment.* Prioritized order: salad bowls, trays, utensils, deli case parts, slicer components, rewrap table components, cutting boards*, and other miscellaneous items.

**Cutting boards should be coated in block whitener (team 4) for >30 minutes before being washed.*

General procedure:

1. Pre-scrape grime, scrub, wash, and rinse utilizing the 3 compartment sink used to clean food contact equipment and utensils
2. Test for ATP response after rinsing, re-clean and retest until ATP passes (<150 RLU)
    a. Not every item cleaned may be tested for ATP, in general the first of each class of item should be test (ex: first deli case door) and every third piece after that depending on quantity and success of cleaning. Frequency of testing to be determined by Purdue staff.
3. Sanitize at 450ppm
4. Allow to air dry in designated clean space

After all dishes and FCS have been washed, clean 3-basin sink completely and test for ATP response

Three (3) Basin sinks

1. Empty sink
2. Scrub interior and exterior by hand using a degreasing agent and chlorinated cleaner
3. Special attention to corners inside sink, underside of exterior edge, faucet and drain
4. Scrub drain
5. Scrub underside of sink, legs, and support bars
    a. Green scouring pads, flat bladed scraper, chlorinated cleaner, and degreasing detergent are recommended
    b. *Hint: Kneeling on a plastic sheet or tote lid can be helpful to reach corners
6. Rinse and test for ATP (if fails, repeat cleaning)
7. Once ATP passes (<150 RLU) sanitize (450ppm)

Team 4 –Priority Tasks

Scales --*To be removed from deli and cleaned by designated team member*--

1. Remove scale from deli work area to designated area away from water.
2. Remove protective cover from keypad –
    a. Cracked, torn, or yellowed covers should be replaced
    b. Keypad cover should be separately washed, rinsed, and sanitized as described below for the whole scale. Then allowed to air dry before being replaced.
3. Scale top may be removed and washed in 3-basin sink by sink crew.
4. Wipe down the body, keypad and other touch points with detergent solution.
    a. Special are for sides and backs of buttons as well as though in recessed areas
    b. NOTE: Take special care to minimize water on the scale keys and not allow water to enter the electrical mechanisms of the unit
5. Rinse with cleaning cloth from rinse bucket to remove all detergent and soils.
6. Test ATP response, reclean until ATP passes (<150RLU)
7. Replace clean scale top on clean scale.
8. Sanitize by using the cleaning cloth from the sanitizer bucket or spray bottle on surfaces that were cleaned and rinsed (450ppm)
9. Allow to air dry.
10. Replace dry keypad cover on dry scale

    ---*Scales should not be returned to deli area until post-final environmental sanitation step*--

Surface cleaning of out-of-scope equipment (fryers, ovens, proofing cabinets)

1. Be careful of water near electronic control panels, and circuits
2. Scrub exterior of equipment with chlorinated cleaner from spray bottles and a scouring pad
    a. Heavy grease may require degreasing agent
3. Rinse carefully with water from hose on waterproof areas;
    a. SENSITIVE areas (i.e. control panels) should be rinsed using a spray bottle only
4. Sanitize (450ppm) –again use spray bottle to dispense sanitizer on sensitive areas

Floor Drains (throughout deli, including CSR)

1. Follow the label directions for all cleaning/sanitizing chemicals and use appropriate PPE.
2. Place disposable gloves on both hands and remove drain cover along with the basket and discard any debris in the basket as well as any debris in the drain.
3. Place drain cover and basket into bucket of chlorinated cleaning solution. Allow to pre-soak per manufacturer's instructions.
4. Scrub drain components inside bucket of solution using scouring pad.
    a. Do NOT use drain brush; this will minimize spatter and risk of cross contamination out of the drain into the department
5. Apply designated drain cleaner or chlorinated cleaner directly to drain and allow contact time per manufacturer's instructions (at least 3-5 minutes).

6. Scrub drain using scouring pad.
    a. Do NOT use drain brush; this will minimize spatter and risk of cross contamination out of the drain into the department
    b. Note: It is NOT recommended to scrub into the drain/sewer line below the base of sink basin.
7. Replace drain basket and cover, if provided.
8. Remove and discard disposable gloves and scouring pads.
9. Wash hands thoroughly.
10. If drain or any component is composed of white PVC pipe:
    a. remove debris by scrubbing as described above
    b. Cover in block whitener paste; allow to soak for at least 30 minutes
    c. Rinse block whitener; reapply and allow longer soak time as needed
11. Rinse the drain cover, basket and drain with a low pressure hot water.
12. Sanitize drain cover, basket and drain (450ppm Quat)
13. Note: drain will be sanitized again concurrently with the room
14. Thoroughly clean and sanitize the bucket used for cleaning drain cover and basket at store's mop sink/janitor's area.

Note: In cases where drain covers cannot be removed safely, apply the "Specialized Drain Cleaning Foam" or soak with block whitener paste as best as possible.

Floor-to-wall juncture under each sink

1. Clean as described above for general floor, scrub thoroughly
2. Add block whitener to fiber-reinforced-plastic (FRP) walls under sinks, and in FTW juncture.
3. Allow block whitener to soak for at least 30 min.
4. Rinse thoroughly with water to remove.
5. Repeat procedure above at least twice (more repetitions as needed)

Assist Teams 1 and 2 with remaining Tables, Shelves and Carts

Tables, Work Surfaces, Racks, and Shelves

1. Fill buckets / spray bottles with detergent solution, rinse water, and sanitizer. Use separate disposable cleaning cloths for each.
2. Flip tables on side to thoroughly scrub bottom, legs, back, and edges of each.
3. Scrub ALL table surfaces with detergent solution.
4. Rinse to remove all detergent and soils.
5. Flip table upright, scrub interior of each shelf, wall, and surface
6. Rinse thoroughly (check bottom shelf for debris)
7. Test for ATP response; re-clean until ATP passes
8. Mark each clean table with designated magnet

Mobile Carts

1. Flip cart on side to scrub wheels and underside of cart frame with detergent.
2. Rinse.
3. Thoroughly scrub the food contact surfaces and cart handle with detergent.
4. Rinse to remove detergent and soils.
5. Test for ATP response, re-clean until surface passes.
6. Mark cleaned and sanitized carts with designated magnet

ALL TEAMS→ Whole Department-Rinse and Sanitize

After completion of all team tasks, available members should begin last environmental scrub down of walls and floors.

Walls

11. Move racks and equipment away from walls
12. Scrub with brushes and detergent
13. Rinse with low pressure hose
14. Test for ATP response (1 per 8 foot section of wall)
15. Return racks and equipment

Floor

9. Apply foaming detergent to floor and walls just above the floor wall junctures. Follow manufacturer's recommendations for concentration, contact time, and water temperature.
10. Vigorously brush the foaming detergent on floor surfaces, floor/wall juncture, under equipment, and all other areas within cold storage room. (designated deck brushes)
11. Rinse all washed areas with low pressure/volume water until all evidence of foam is removed.
12. Squeegee excess water toward drains. Avoid splashing of all chemicals and water.
13. Test for ATP response

Whole Department Last over

1. Refill boot dip-station (450ppm)
2. Refill tool sanitation station (450ppm)
3. Submerse all brushes, buckets, and tools remaining in department in fresh sanitizer
4. Discard used scouring pads, disposable gloves and other worn equipment
5. Rinse all surfaces thoroughly with water top to bottom.
6. Sanitize food contact surfaces and equipment using spray bottles (counter tops, slicer, rewrap tables, deli case exterior, employee touchpoints, exterior of ovens, fryers, and other out-of-scope equipment)

2. Return all cleaning equipment (buckets, brushes, squeegees, hoses) to designated storage areas
3. All workers exit deli, except sanitizing team
4. Sanitize walls, floors, large equipment using mobile cart or foaming unit (450ppm)
    a. Work top to bottom, back to front. Plan path through deli to move progressively closer to hose storage area and a quick exit from deli with minimal traffic across newly cleaned and sanitized deli floor
    b. Sanitize hose concurrently with floor

Deli Reassembly (2-3 hours)

Allow a break for deli floors and other items to air dry after last sanitizer application and workers to recover before reassembly begins.

All cleaning crew members must wash hands before beginning work

1. Wash with soap and warm water to scrub hands, between fingers, under fingernails for 20 seconds (sing Happy Birthday song twice)
2. Use a clean paper towel to dry hands and turn off faucet
3. Use paper towel to handle door knobs when exiting the restroom.

Deli Reassembly

1. Replace sanitized scales in sanitized deli area.
2. Check functionality of: scales, slicer, rewrap table, deli cases, cold storage room and other sensitive equipment

Team 1 -> Return product to Cold Storage Room and label shelves accordingly

Team 2 -> Return meat and cheese products to deli cases

Team 3 -> Assist Team 1 and Team 2

Team 4 -> Return paperwork and dry goods to deli; Reset labeling and pricing for deli.

During last 30 minutes of work

Debriefing Assessment

1. Meet with all team members who participated in cleaning event
2. Method/SSOP Assessment
    a. Achievements/Accomplishments
    b. Observed Challenges and Solutions; Items/Procedures to change next time

Post-Cleaning Sample Collection

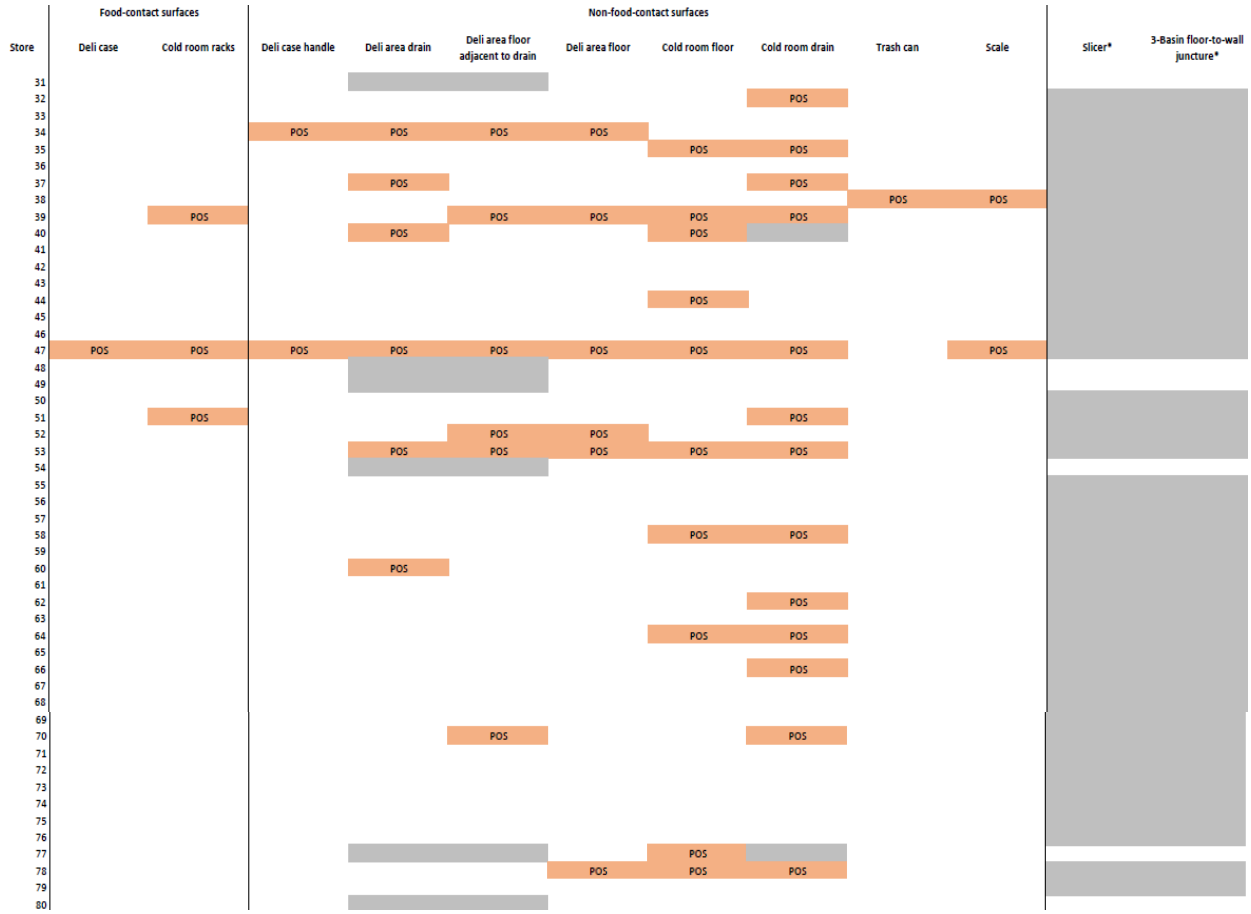
1. Swab for residual ATP and LM "post-deep clean"
    a. Completed by Purdue team or trained personnel
    b. 28 LM sites
        i. ATP will not be collect post-deep clean as sanitizer creates false-positives

ACKNOWLEDGEMENTS

This protocol was adopted from ECOLAB's "*Listeria* Recovery Cleaning Procedure", FMI Listeria Working Group SSOPs and input from Maple Leaf Foods. Special thanks to Steven Tsuyuki, Randy Hoffman, Tom Ford, Michael T. Howard, and Michael Riddley for their time and contributions to this project.

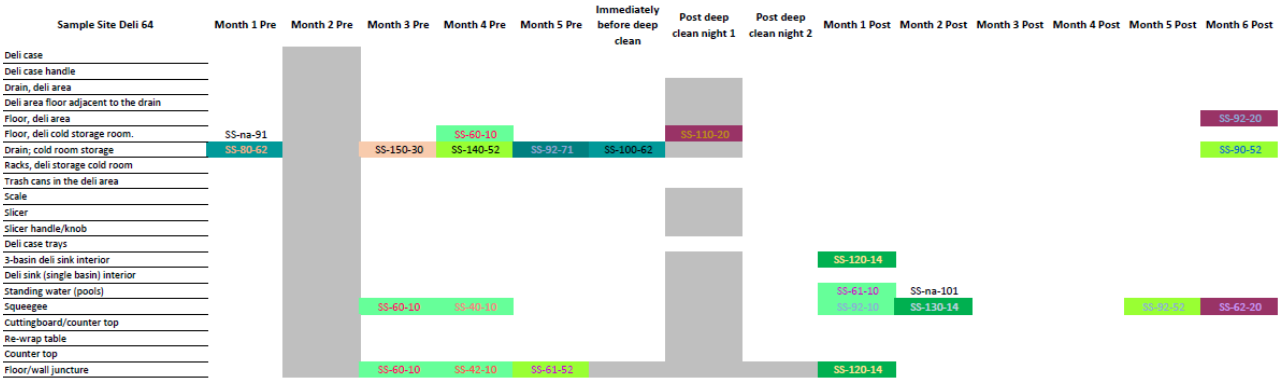
APPENDIX D. *L. MONOCYTOGENES* POSITIVE SAMPLES IN INITIAL SCREENING PHASE

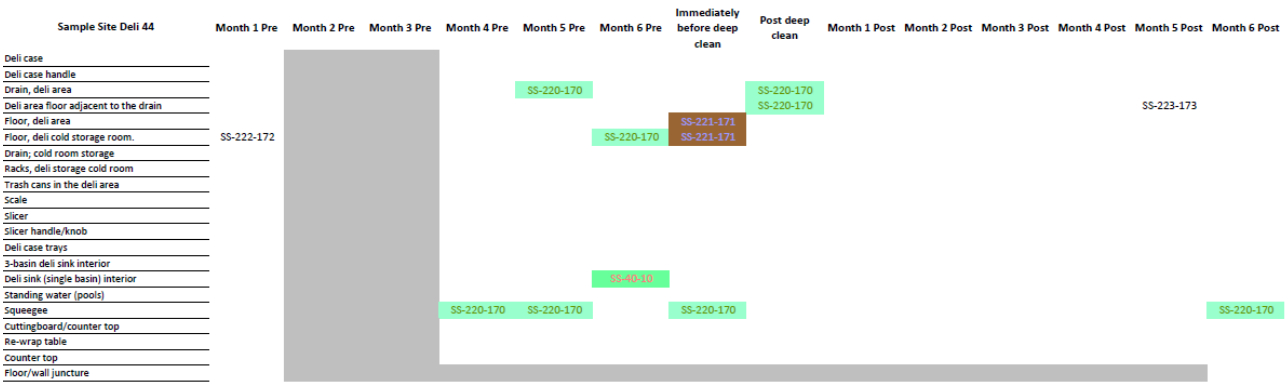
L. monocytogenes positive samples by site by deli during initial Screening Phase. Screening model sites were tested in 50 stores during the initial screen. Sites marked with * were sampled only if deli area floor drain was not present. "POS" is designated to *L. monocytogenes* positive sample; grey cells are designated to sites not sampled.

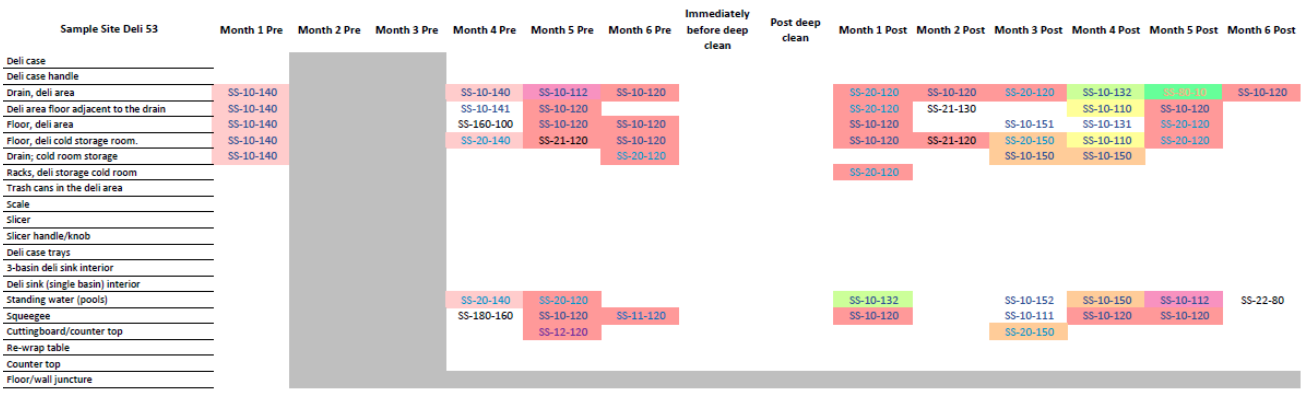


APPENDIX E. PULSOTYPE MAPS FOR THE SEVEN DELIS OF HIGH *L. MONOCYTOGENES* PREVALENCE

Pulsotype maps for the seven delis of high *L. monocytogenes* prevalence throughout the study period. Pulsotypes of isolates were compared within the study and expressed as SS-*Asc*I#-*Apa*I#.







Sample Site Deli 40	Month 1 Pre	Month 2 Pre	Month 3 Pre	Month 4 Pre	Month 5 Pre	Immediately before deep clean	Post deep clean	Month 1 Post	Month 2 Post	Month 3 Post	Month 4 Post	Month 5 Post	Month 6 Post
Deli case													
Deli case handle													
Drain, deli area	SS-91-10		SS-90-10	SS-90-10		SS-60-10						SS-41-12	
Deli area floor adjacent to the drain			SS-90-10			SS-60-10					SS-200-104		
Floor, deli area													
Floor, deli cold storage room.	SS-91-10		SS-90-11	SS-90-10	SS-60-10								
Drain; cold room storage													
Racks, deli storage cold room													
Trash cans in the deli area				SS-90-10									
Scale													
Slicer													
Slicer handle/knob													
Deli case trays													
3-basin deli sink interior													
Deli sink (single basin) interior													
Standing water (pools)				SS-70-10									
Squeegee													
Cuttingboard/counter top													
Re-wrap table													
Counter top													
Floor/wall juncture													

Sample Site Deli 39	Month 1 Pre	Month 2 Pre	Month 3 Pre	Month 4 Pre	Month 5 Pre	Immediately before deep clean	Post deep clean	Month 1 Post	Month 2 Post	Month 3 Post	Month 4 Post	Month 5 Post	Month 6 Post
Deli case													
Deli case handle													
Drain, deli area				SS-40-20	SS-80-60	SS-80-40			SS-40-90				
Deli area floor adjacent to the drain	SS-80-60			SS-80-31	SS-31-60	SS-30-40	SS-100-70	SS-80-60	SS-80-70		SS-31-60		
Floor, deli area	SS-80-60			SS-80-70	SS-80-70	SS-30-40							
Floor, deli cold storage room.	SS-80-60					SS-30-40			SS-80-70				
Drain; cold room storage	SS-80-60		SS-80-70	SS-80-60	SS-80-70	SS-30-40				SS-80-21	SS-30-40	SS-30-40	SS-30-40
Racks, deli storage cold room	SS-80-61		SS-80-60										
Trash cans in the deli area												SS-30-72	
Scale													
Slicer						SS-40-50							
Slicer handle/knob													
Deli case trays													
3-basin deli sink interior													
Deli sink (single basin) interior													
Standing water (pools)				SS-80-70									
Squeegee			SS-80-60	SS-80-70	SS-80-60	SS-110-40			SS-80-32		SS-30-40		SS-31-72
Cuttingboard/counter top													
Re-wrap table													
Counter top													
Floor/wall juncture				SS-80-71	SS-80-60								

Sample Site Deli 37	Month 1 Pre	Month 2 Pre	Month 3 Pre	Month 4 Pre	Month 5 Pre	Immediately before deep clean	Post deep clean	Month 1 Post	Month 2 Post	Month 3 Post	Month 4 Post	Month 5 Post	Month 6 Post
Deli case													
Deli case handle													
Drain, deli area	SS-71-50		SS-70-20	SS-71-21	SS-40-20			SS-80-20	SS-40-41	SS-40-20	SS-40-20	SS-40-40	SS-40-20
Deli area floor adjacent to the drain				SS-70-20		SS-40-20		SS-40-40		SS-40-10	SS-40-20	SS-40-40	SS-40-20
Floor, deli area						SS-40-20					SS-40-40		SS-40-20
Floor, deli cold storage room.											SS-40-20		
Drain; cold room storage	SS-71-21		SS-190-40						SS-40-40	SS-40-20			SS-210-103
Racks, deli storage cold room											SS-40-61		
Trash cans in the deli area										SS-40-20			
Scale													
Slicer													
Slicer handle/knob													
Deli case trays													
3-basin deli sink interior													
Deli sink (single basin) interior				SS-71-41									
Standing water (pools)			SS-70-20			SS-40-20	SS-40-20			SS-40-40	SS-40-40		
Squeegee				SS-40-51	SS-40-20	SS-40-40			SS-40-20	SS-40-20	SS-40-41	SS-40-20	SS-40-20
Cuttingboard/counter top													
Re-wrap table				SS-80-60									
Counter top													
Floor/wall juncture			SS-70-20		SS-40-20			SS-40-20	SS-40-20	SS-40-20	SS-40-20	SS-70-20	SS-40-20

Sample Site Deli 35	Month 1 Pre	Month 2 Pre	Month 3 Pre	Month 4 Pre	Month 5 Pre	Immediately before deep clean	Post deep clean night 1	Post deep clean night 2	Month 1 Post	Month 2 Post	Month 3 Post	Month 4 Post	Month 5 Post	Month 6 Post
Deli case														
Deli case handle														
Drain, deli area								SS-40-50						
Deli area floor adjacent to the drain								SS-40-50						
Floor, deli area								SS-40-50					SS-40-50	
Floor, deli cold storage room.	SS-60-50			SS-120-14		SS-40-10	SS-40-13							
Drain; cold room storage	SS-60-10				SS-190-20	SS-40-10								
Racks, deli storage cold room														
Trash cans in the deli area														
Scale														
Slicer														
Slicer handle/knob														
Deli case trays														
3-basin deli sink interior									SS-81-22					
Deli sink (single basin) interior														
Standing water (pools)								SS-40-10						
Squeegee			SS-60-10	SS-81-22										SS-80-20
Cuttingboard/counter top														
Re-wrap table														
Counter top			SS-80-62											
Floor/wall juncture			SS-80-62											SS-80-20

APPENDIX F. PULSOTYPE-ISOLATE KEY

Pulsotype-isolate key for all the environmental *L. monocytogenes* isolates sampled from the seven high-prevalence delis. Pulsotypes of isolates were compared within the study and expressed as SS-*Asc*I#-*Apa*I#.

Isolate	Store	Period	Site	Surface type	SS-AscI#-ApaI#
PUL H1-1201	35	Screening	Drain; cold room storage	NFCS	SS-060-010
PUL H1-1197	35	Screening	Floor, deli cold storage room.	NFCS	SS-060-050
PUL H1-1359	35	Baseline Monitoring	Squeegee	NFCS	SS-060-010
PUL H1-1363	35	Baseline Monitoring	Counter top	FCS	SS-080-062
PUL H1-1367	35	Baseline Monitoring	Floor/wall juncture under 3-basin deli sink	NFCS	SS-080-062
PUL H1-1636	35	Baseline Monitoring	Squeegee	NFCS	SS-081-022
PUL H1-1632	35	Baseline Monitoring	Floor, deli cold storage room.	NFCS	SS-120-014
PUL H1-2013	35	Baseline Monitoring	Drain; cold room storage	NFCS	SS-190-020
PUL H1-2388	35	Pre-DC	Floor, deli cold storage room.	NFCS	SS-040-010
PUL H1-2462	35	Pre-DC	Drain; cold room storage	NFCS	SS-040-010
PUL H1-2408	35	Post-DC (night2)	Standing water (pools)	NFCS	SS-040-010
PUL H1-2392	35	Post-DC (night1)	Floor, deli cold storage room.	NFCS	SS-040-013
PUL H1-2396	35	Post-DC (night2)	Drain, deli area	NFCS	SS-040-050
PUL H1-2404	35	Post-DC (night2)	Floor, deli area	NFCS	SS-040-050
PUL H1-2400	35	Post-DC (night2)	Deli area floor adjacent to the drain	NFCS	SS-040-050
PUL H1-2756	35	Follow-up	Floor, deli area	NFCS	SS-040-050
PUL H1-2856	35	Follow-up	Squeegee	NFCS	SS-080-020
PUL H1-2860	35	Follow-up	Floor/wall juncture under 3-basin deli sink	NFCS	SS-080-020
PUL H1-2480	35	Follow-up	3-basin deli sink interior	FCS	SS-081-022
PUL H1-1211	37	Screening	Drain; cold room storage	NFCS	SS-071-021
PUL H1-1207	37	Screening	Drain, deli area	NFCS	SS-071-050
PUL H1-2023	37	Baseline Monitoring	Squeegee	NFCS	SS-040-020
PUL H1-2017	37	Baseline Monitoring	Drain, deli area	NFCS	SS-040-020
PUL H1-2027	37	Baseline Monitoring	Floor/wall juncture under 3-basin deli sink	NFCS	SS-040-020
PUL H1-1652	37	Baseline Monitoring	Squeegee	NFCS	SS-040-051
PUL H1-1644	37	Baseline Monitoring	Deli area floor adjacent to the drain	NFCS	SS-070-020
PUL H1-1371	37	Baseline Monitoring	Drain, deli area	NFCS	SS-070-020
PUL H1-1383	37	Baseline Monitoring	Standing water (pools)	NFCS	SS-071-020
PUL H1-1389	37	Baseline Monitoring	Floor/wall juncture under 3-basin deli sink	NFCS	SS-071-020
PUL H1-1640	37	Baseline Monitoring	Drain, deli area	NFCS	SS-071-021
PUL H1-1648	37	Baseline Monitoring	Deli sink (single basin) interior	FCS	SS-071-041
PUL H1-1656	37	Baseline Monitoring	Re-wrap table	FCS	SS-080-060
PUL H1-1379	37	Baseline Monitoring	Drain; cold room storage	NFCS	SS-190-040
PUL H1-2360	37	Pre-DC	Drain, deli area	NFCS	SS-040-020
PUL H1-2364	37	Pre-DC	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-2368	37	Pre-DC	Squeegee	NFCS	SS-040-020
PUL H1-2376	37	Post-DC	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-2380	37	Post-DC	Floor, deli area	NFCS	SS-040-020
PUL H1-2372	37	Post-DC	Drain, deli area	NFCS	SS-072-020
PUL H1-2384	37	Post-DC	Standing water (pools)	NFCS	SS-073-020
PUL H1-2618	37	Follow-up	Drain, deli area	NFCS	SS-040-020

PUL H1-2622	37	Follow-up	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-2626	37	Follow-up	Squeegee	NFCS	SS-040-020
PUL H1-2692	37	Follow-up	Drain, deli area	NFCS	SS-040-020
PUL H1-2696	37	Follow-up	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-2700	37	Follow-up	Floor, deli area	NFCS	SS-040-020
PUL H1-2708	37	Follow-up	Squeegee	NFCS	SS-040-020
PUL H1-2770	37	Follow-up	Floor, deli cold storage room.	NFCS	SS-040-020
PUL H1-2774	37	Follow-up	Squeegee	NFCS	SS-040-020
PUL H1-2778	37	Follow-up	Floor/wall juncture under 3-basin deli sink	NFCS	SS-040-020
PUL H1-2562	37	Follow-up	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-2712	37	Follow-up	Slicer handle/knob	FCS	SS-040-020
PUL H1-2484	37	Follow-up	Squeegee	NFCS	SS-040-020
PUL H1-2558	37	Follow-up	Drain, deli area	NFCS	SS-040-020
PUL H1-2566	37	Follow-up	Squeegee	NFCS	SS-040-020
PUL H1-2570	37	Follow-up	Floor/wall juncture under 3-basin deli sink	NFCS	SS-040-020
PUL H1-2766	37	Follow-up	Floor, deli area	NFCS	SS-040-040
PUL H1-2630	37	Follow-up	Floor/wall juncture under 3-basin deli sink	NFCS	SS-062-020
PUL H1-2760	37	Follow-up	Drain, deli area	NFCS	SS-170-102
PUL H1-2840	37	Pre-DC#2	Floor, deli area	NFCS	SS-040-020
PUL H1-2844	37	Pre-DC#2	Standing water (pools)	NFCS	SS-040-020
PUL H1-2836	37	Pre-DC#2	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-2848	37	Pre-DC#2	Squeegee	NFCS	SS-040-040
PUL H1-2852	37	Post-DC#2	Standing water (pools)	NFCS	SS-040-020
PUL H1-3003	37	Follow-up (DC#2)	Deli area floor adjacent to the drain	NFCS	SS-040-010
PUL H1-2872	37	Follow-up (DC#2)	Floor/wall juncture under 3-basin deli sink	NFCS	SS-040-020
PUL H1-3023	37	Follow-up (DC#2)	Floor/wall juncture under 3-basin deli sink	NFCS	SS-040-020
PUL H1-3081	37	Follow-up (DC#2)	Floor/wall juncture under 3-basin deli sink	NFCS	SS-040-020
PUL H1-3135	37	Follow-up (DC#2)	Drain, deli area	NFCS	SS-040-020
PUL H1-3139	37	Follow-up (DC#2)	Deli area floor adjacent to the drain	NFCS	SS-040-020
PUL H1-3143	37	Follow-up (DC#2)	Floor, deli area	NFCS	SS-040-020
PUL H1-3149	37	Follow-up (DC#2)	Squeegee	NFCS	SS-040-020

APPENDIX G. RETAIL FOOD SAFETY CULTURE AND CLIMATE SURVEY

Q1 Date Received (mm/dd/yy)

Q16 Survey Number (overall)

Q3 Corporate Store Number (ex: S-239)

Q4 Food Safety Practices

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
1. Employees are committed to the food safety program. (1)	❍	❍	❍	❍	❍
2. Employees encourage each other to follow food safety rules. (2)	❍	❍	❍	❍	❍
3. Employees take responsibility for proper food handling in their work areas. (3)	❍	❍	❍	❍	❍
4. Employees will tell a manager when a food safety problem happens. (4)	❍	❍	❍	❍	❍
5. Even if no one was looking, employees would follow all the food safety rules. (5)	❍	❍	❍	❍	❍
6. Food safety rules are hard for employees to understand. (6)	❍	❍	❍	❍	❍
7. Management is committed to serving safe food. (7)	❍	❍	❍	❍	❍

8. Management makes sure employees follow food safety rules all the time. (8)	❍	❍	❍	❍	❍
9. Management stresses food safety rules even when the restaurant is busy. (9)	❍	❍	❍	❍	❍
10. Management makes sure employees have the equipment and/or tools needed to follow the food safety rules. (10)	❍	❍	❍	❍	❍
11. Management often checks to see that all employees are following the food safety rules. (11)	❍	❍	❍	❍	❍
12. Management praises employees who pay special attention to food safety. (12)	❍	❍	❍	❍	❍

13. Management sometimes encourage employees to do things that are against the food safety rules. (13)	❍	❍	❍	❍	❍
14. Management sometimes looks the other way when employees are not following food safety rules. (14)	❍	❍	❍	❍	❍
15. Even if no one was looking, management would follow all the food safety rules. (15)	❍	❍	❍	❍	❍
16. I know when I should wash my hands to protect the food from contamination. (16)	❍	❍	❍	❍	❍
17. I know why I should wash my hands to protect the food from contamination. (17)	❍	❍	❍	❍	❍
18. When the restaurant is busy, I still wash my hands as much as I should. (18)	❍	❍	❍	❍	❍

19. Management asks for help from employees to improve our food safety program. (19)	❍	❍	❍	❍	❍
20 I always consider food safety when I am doing my job. (20)	❍	❍	❍	❍	❍
21. I believe it is important for me to follow all the food safety rules, not just the most important ones. (21)	❍	❍	❍	❍	❍
22. I believe that how well I do my job can affect the safety of the food the customer receives. (22)	❍	❍	❍	❍	❍
23. I completely support our food safety program. (23)	❍	❍	❍	❍	❍
24. I know food safety problems can happen if I do not do my job correctly. (24)	❍	❍	❍	❍	❍

25. I know when I should change my gloves to protect the food from contamination. (25)	❍	❍	❍	❍	❍
26. I know why I should change my gloves to protect the food from contamination. (26)	❍	❍	❍	❍	❍
27. Employees receive the proper training to follow the food safety rules. (27)	❍	❍	❍	❍	❍
28. New employees receive all the training they need to perform their jobs according to food safety rules. (28)	❍	❍	❍	❍	❍
29. The food safety training provided gives us the necessary skills and/or knowledge to follow the food safety rules. (29)	❍	❍	❍	❍	❍

30. Management encourages employees to report all food safety problems. (30)	❍	❍	❍	❍	❍
31. Management believes that food safety is very important. (31)	❍	❍	❍	❍	❍
32. Management shows leadership by keeping employees focused on food safety. (32)	❍	❍	❍	❍	❍
33. Management visibly shows support for food safety ("walks the talk"). (33)	❍	❍	❍	❍	❍
34. Management follows all the food safety rules in the restaurant. (34)	❍	❍	❍	❍	❍
35. Management provides adequate-tools for training and/or education for food safety. (35)	❍	❍	❍	❍	❍

36. The organization learns and makes changes when mistakes are found in food safety. (36)	❍	❍	❍	❍	❍
37. Equipment is designed to allow for proper cleaning. (37)	❍	❍	❍	❍	❍
38. The pest control program is effective so there is no sign of rodents and/or insects in the restaurant. (38)	❍	❍	❍	❍	❍

Q5 Part B:

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
1. Management at this restaurant follows the food safety rules. (1)	❍	❍	❍	❍	❍
2. Employees at this restaurant follow the food safety rules. (2)	❍	❍	❍	❍	❍
3. Employees do things that contaminate food by not following food safety rules. (3)	❍	❍	❍	❍	❍
4. Employees chew gum or eat snacks in the kitchen. (4)	❍	❍	❍	❍	❍
5. Employees do not washing their hands when they can get away with it. (5)	❍	❍	❍	❍	❍
6. Employees wear their hats or hair nets so they cover their ears and keep their hair in place. (6)	❍	❍	❍	❍	❍

Q6 How many years have you worked in food service?

- ❍ Less than 1 year (1)
- ❍ 1 -5 years (2)
- ❍ 6-10 years (3)
- ❍ 11-15 years (4)
- ❍ More than 15 years (5)

Q7 How you ever had food safety training?

- ❍ Yes (1)
- ❍ No (2)

Q8 If, YES, which of the following best describes the training?

- ❑ Face-to-face class (1)
- ❑ video (2)
- ❑ computer/internet (3)
- ❑ printed materials (4)
- ❑ Demonstration/advise (5)
- ❑ Job orientation (6)
- ❑ Not applicable. No food safety training (7)

Q9 Have you ever been certified in food safety (such as Serv Safe?)

- ❍ Yes (1)
- ❍ No (2)

Q10 How long have you been employed at your current food service establishment?

- ❍ less than 1 year (1)
- ❍ 1-5 Years (2)
- ❍ 6-10 years (3)
- ❍ 11-15 years (4)
- ❍ More than 15 years (5)

Q11 What is your current position title?

- ❍ Kitchen Manager (1)
- ❍ Assistant kitchen manager (2)
- ❍ Cook/line cook (3)
- ❍ Food prep (4)
- ❍ Foodservice assistant (5)
- ❍ Dishwasher (6)
- ❍ Server (7)
- ❍ Deli Manager (8)
- ❍ Deli associate (9)
- ❍ Other (please specify) (10) _____

Q12 How long have you been in this position?

- ❍ Less than 1 year (1)
- ❍ 1-5 years (2)
- ❍ 6-10 years (3)
- ❍ 11-15 years (4)
- ❍ More than 15 years (5)

Q13 In what year were you born? (ex: 1992)

Q17 Gender

- ❍ Male (1)
- ❍ Female (2)

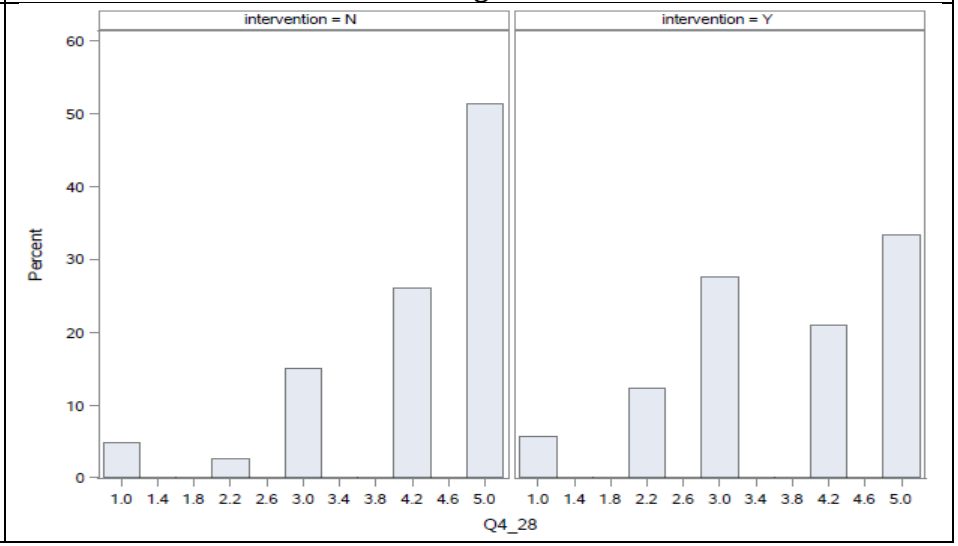
Q14 Which of the following best describes your ethnic identification?

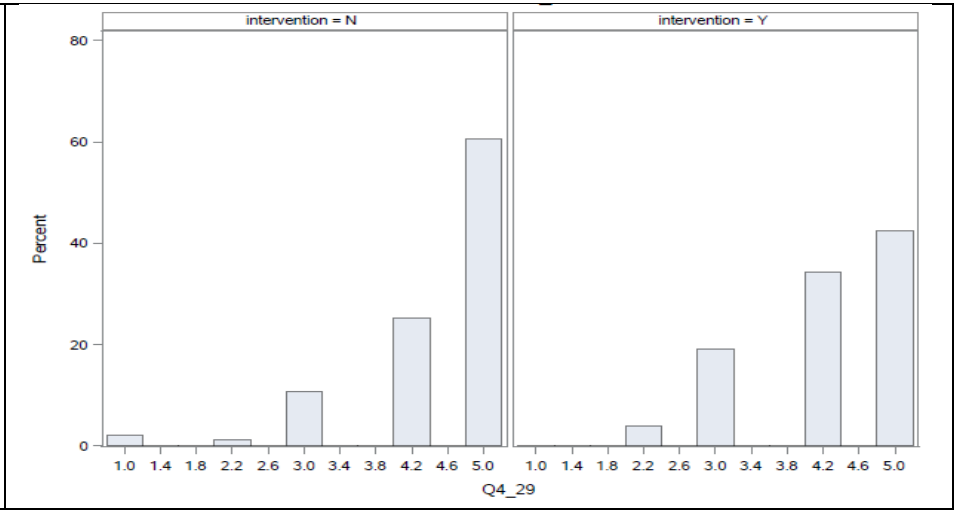
- ❍ African American (1)
- ❍ Asian/Pacific Islander (2)
- ❍ White/Non-Hispanic (3)
- ❍ Hispanic (4)
- ❍ Native American (5)
- ❍ Other (please specify) (6) _____

Q15 What is the highest level of education you have received?

- ❍ Less than high school (1)
- ❍ Some high school (2)
- ❍ High school diploma (3)
- ❍ Vocational/Technical School (4)
- ❍ Some college/Associate degree (5)
- ❍ Undergraduate degree (B.A., B.S., etc) (6)
- ❍ Other (please specify) (7) _____

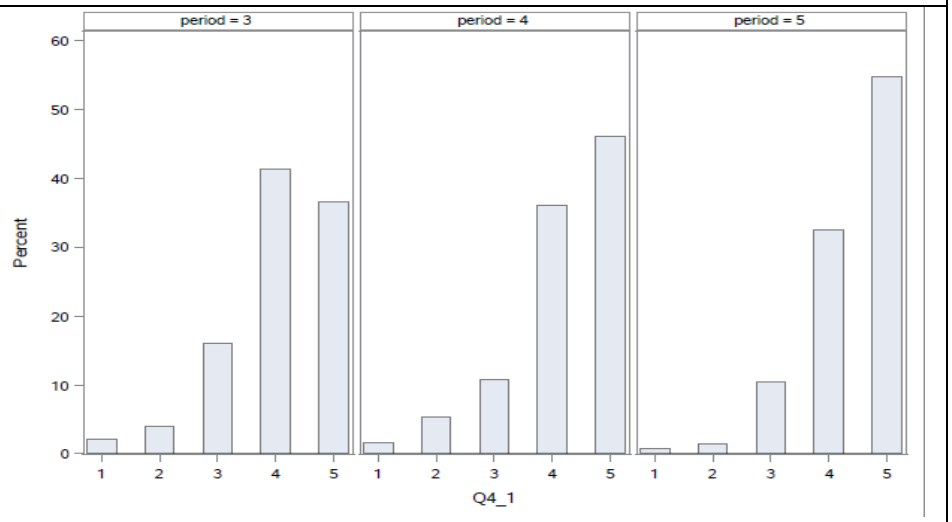
APPENDIX H. SIGNIFICANT SURVEY VARIABLES CORRELATED TO L. MONOCYTOGENES CONTAMINATION RISK

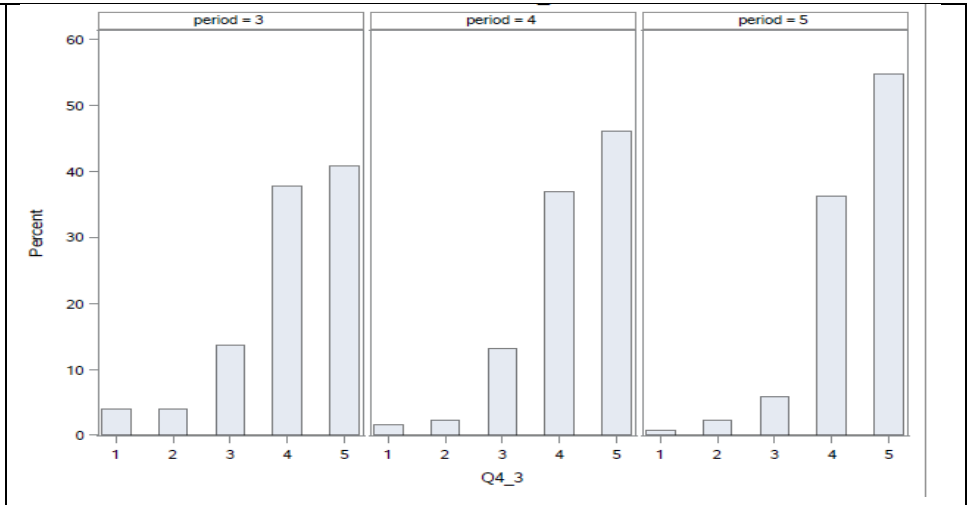
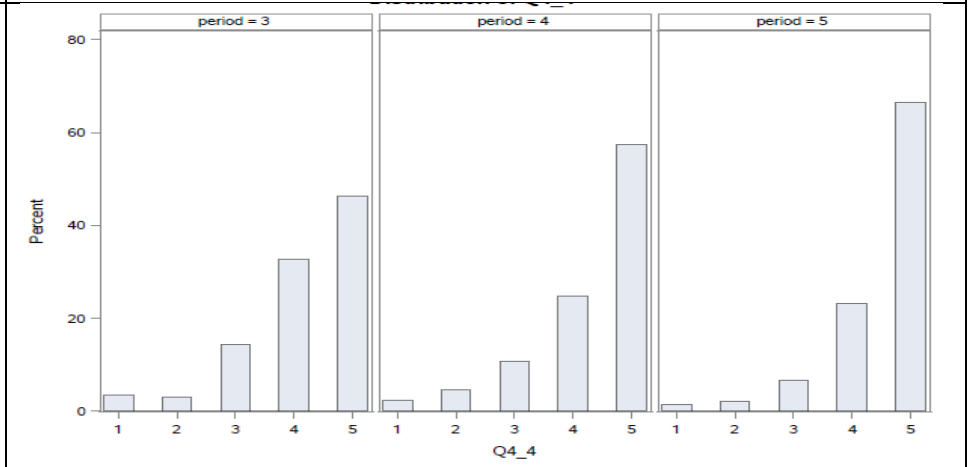
ID[a]	Outcomes[b]	p value[c]	Histogram[d]
Q4_28	Training for new employees reported more likely to cover all that they need to perform their jobs according to food safety rules in delis of low *L. monocytogenes* risk than those of high risk.	0.0117	

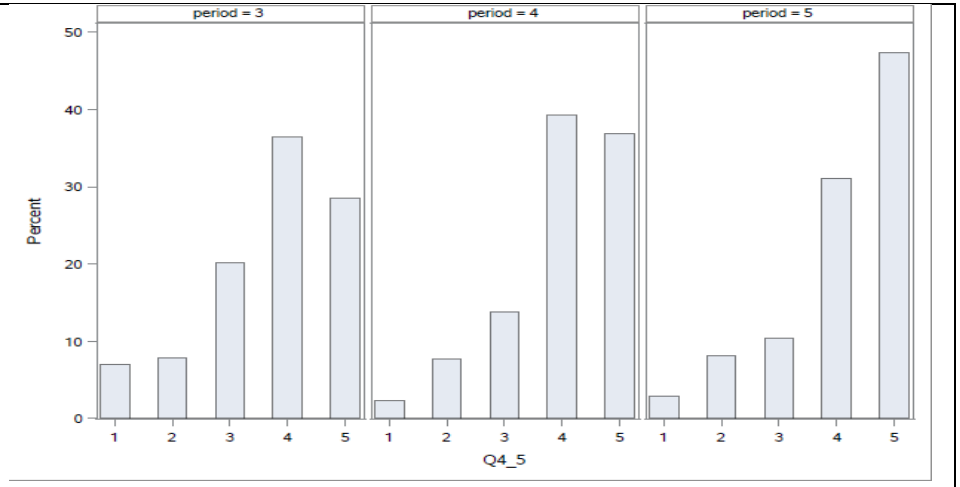
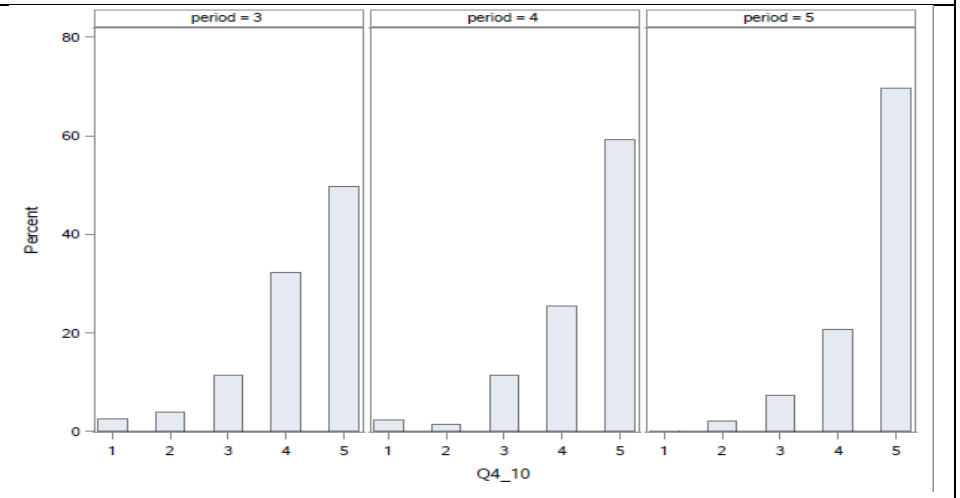
Q4_29	Food safety training reported more likely to provide "us" the necessary skills and/or knowledge to follow the food safety rules in delis of low *L. monocytogenes* risk than those of high risk.	0.0177	

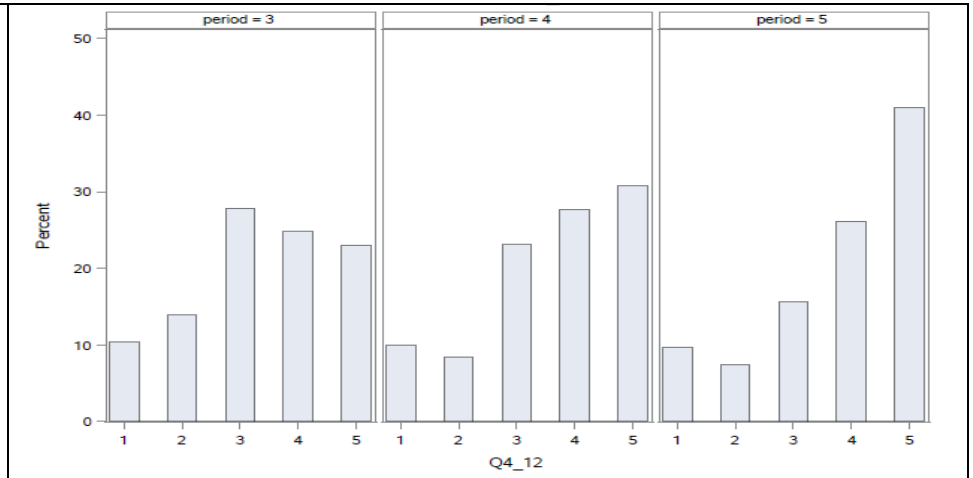
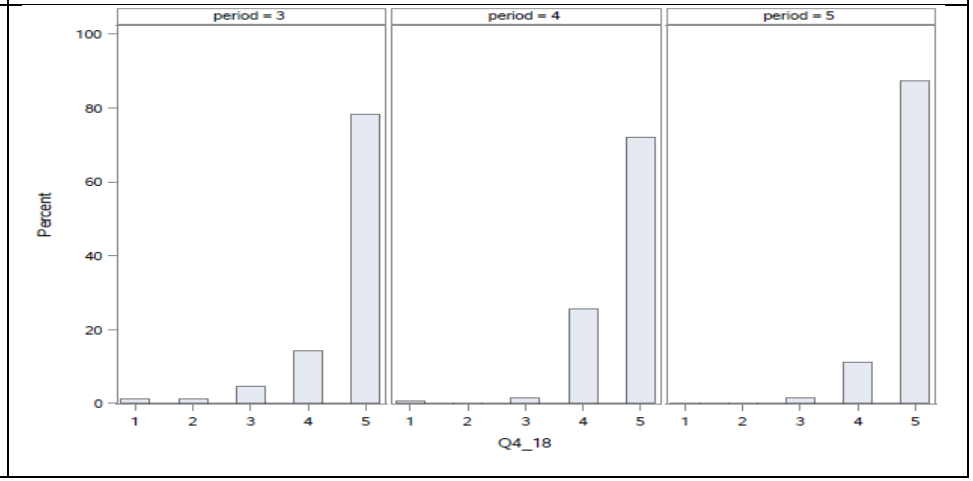
[a] All survey questions that were significantly correlated with *L. monocytogenes* contamination risk were listed with $p<0.05$, both questions are under "organizational climate" factor from principal component analysis;
[b] Context of the significant effects based on correlation analysis;
[c] Unadjusted overall p-values of each significant variables ($p<0.05$);
[d] Survey response distribution by *L. monocytogenes* contamination risk, with "intervention=Y" designated to high *L. monocytogenes* contamination risk, and "intervention=N" low risk, higher value in the Likert-scale survey response meaning more agreeable to the statement.

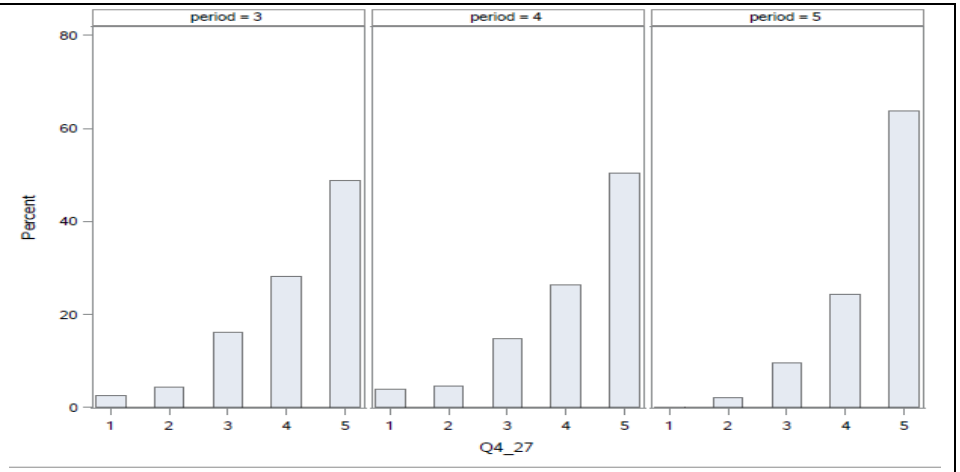
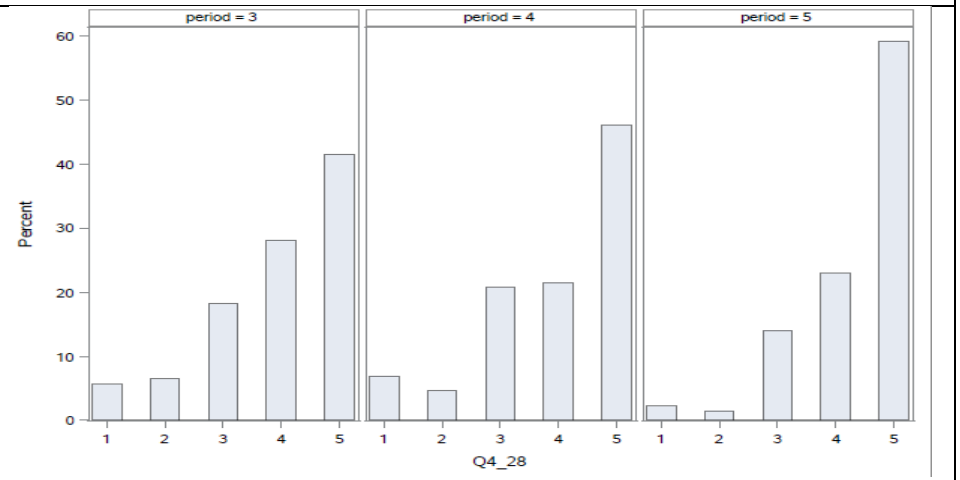
APPENDIX I. SURVEY VARIABLES THAT SIGNIFICANTLY CHANGED THROUGH THE STUDY PERIODS

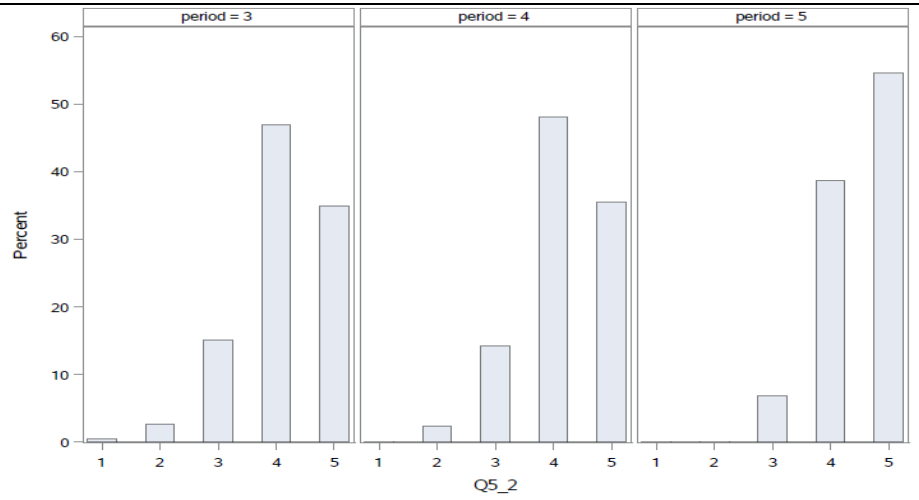
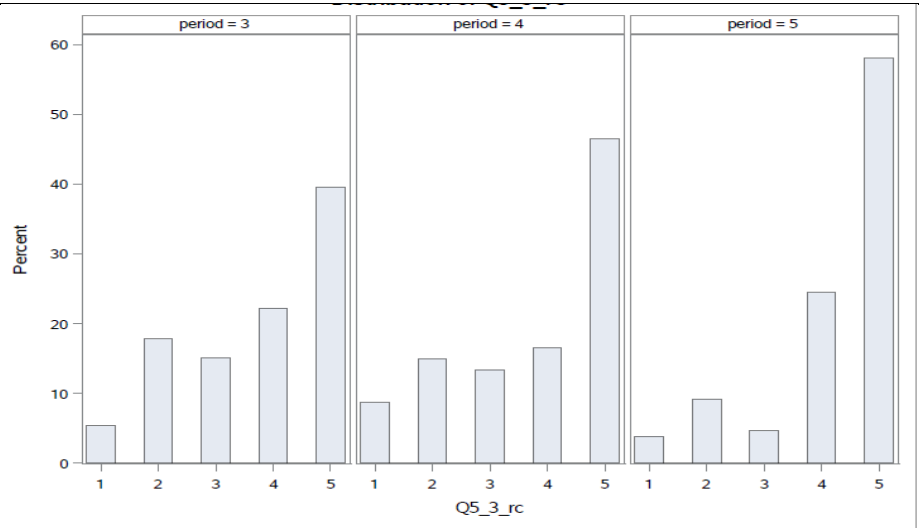
ID[a]	Outcomes[b]	p value[c]	Histogram[d]
Q4_1	Employees reported to have greater commitment to food safety program during follow-up than immediately before deep clean (p_{adj}=0.0057).	0.0112	

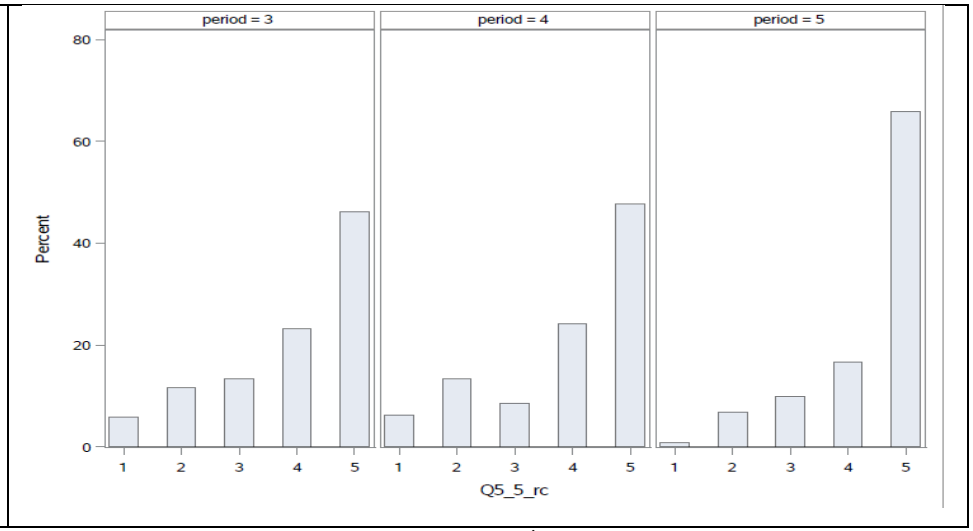
Q4_3	Employees reported to take greater responsibility for proper food handling in their work area during follow-up than immediately before deep clean (p_{adj}=0.0103).	0.0198	
Q4_4	Employees reported a greater likelihood to tell a manager when a food safety problem happened during follow-up than immediately before deep clean (p_{adj}=0.0022).	0.0043	

Q4_5	Employees reported more likely to follow all food safety rules even if no one was looking during follow-up than immediately before deep clean (p_{adj}=0.0055).	0.0108	
Q4_10	Management was more likely to make sure employees have the equipment and/or tools needed to follow the food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0243).	0.0378	

Q4_12	Management was more likely to praise employees who pay special attention to food safety during follow-up than immediately before deep clean (p_{adj}<0.0001).	0.0002	
Q4_18†	Participants were more likely to agree that "I still washed my hands as much as I should when it was busy" immediately before deep clean than immediately after deep clean (p_{adj}=0.0356).	0.0055	

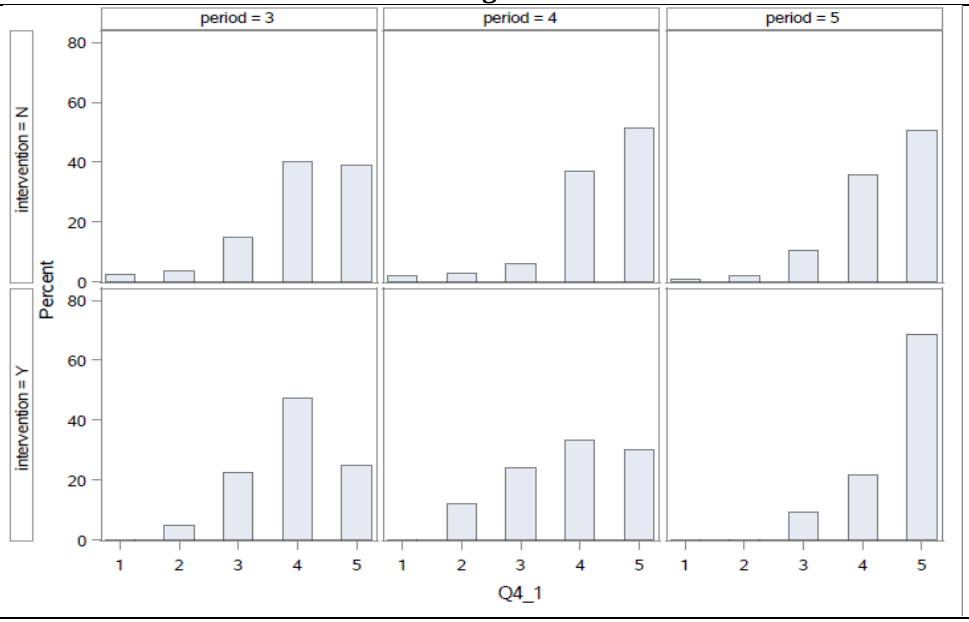
Q4_27	Employees reported more likely to receive the proper training to follow the food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0291).	0.0444	
Q4_28	Training for new employees was reported more likely to cover all that they needed to perform their jobs according to food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0053).	0.0068	

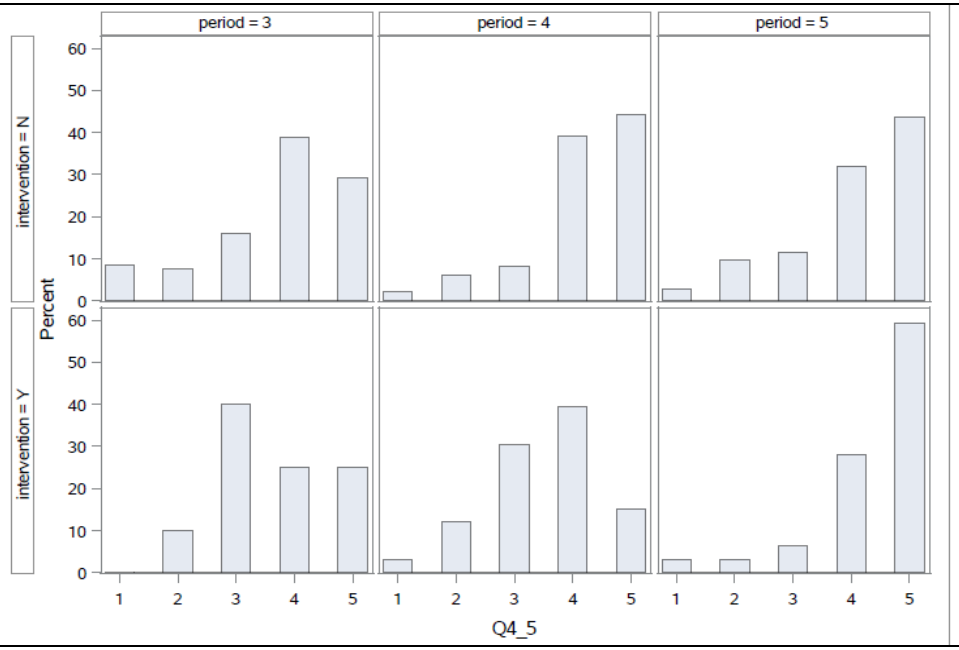
Q5_2	Employees at the workplace reported more likely to follow the food safety rules during follow-up than immediately before deep clean (p_{adj}=0.0004).	0.0004	
Q5_3_rc	Employees reported more likely to not follow food safety rules and contaminate food immediately before deep clean than during follow-up (p_{adj}=0.0160).	0.0183	

Q5_5_rc	Employees reported more likely to not wash their hands when they can get away with it immediately before deep clean than during follow-up (p_{adj}=0.0034).	0.0035	

[a] All survey questions that were significantly correlated with study period were listed with p<0.05, † designated to the question under "individual's behavior" factor from principal component analysis, all else questions are under "organizational climate" factor;
[b] Context of the significant effects based on correlation analysis, Bonferroni adjustment was applied for multiple comparisons;
[c] Unadjusted overall p-values of each significant variables (p<0.05);
[d] Survey response distribution by study period, with "period=3" designated to immediately before deep clean, "period=4" immediately after deep clean, "period=5" 6-month follow-up; higher value in the Likert-scale survey response meaning more agreeable to the statement.

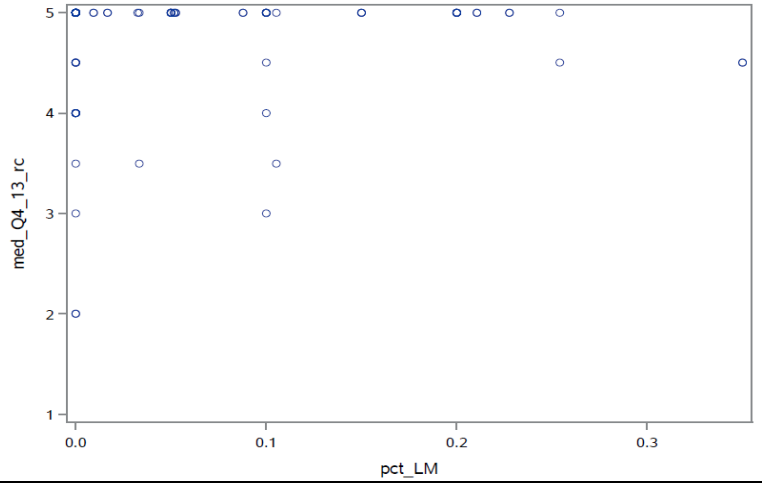
APPENDIX J. SIGNIFICANT SURVEY VARIABLES CORRELATED WITH L. MONOCYTOGENES CONTAMINATION RISK ACROSS STUDY PERIODS

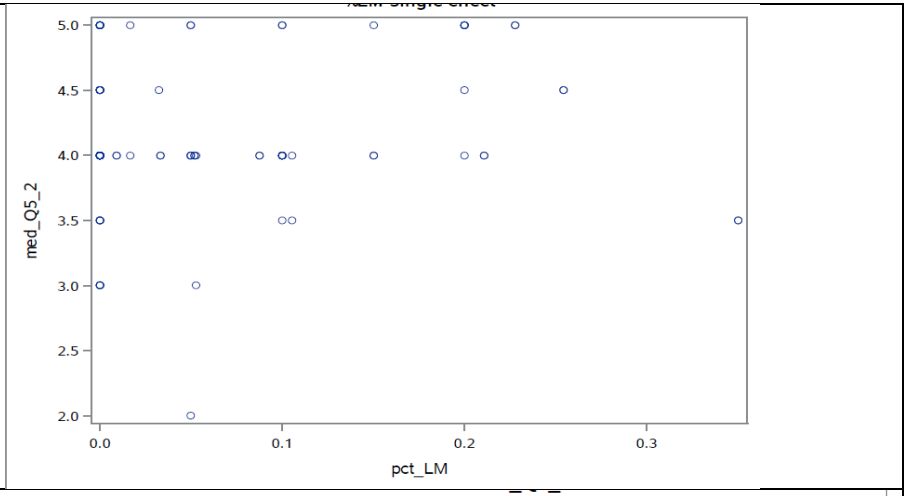
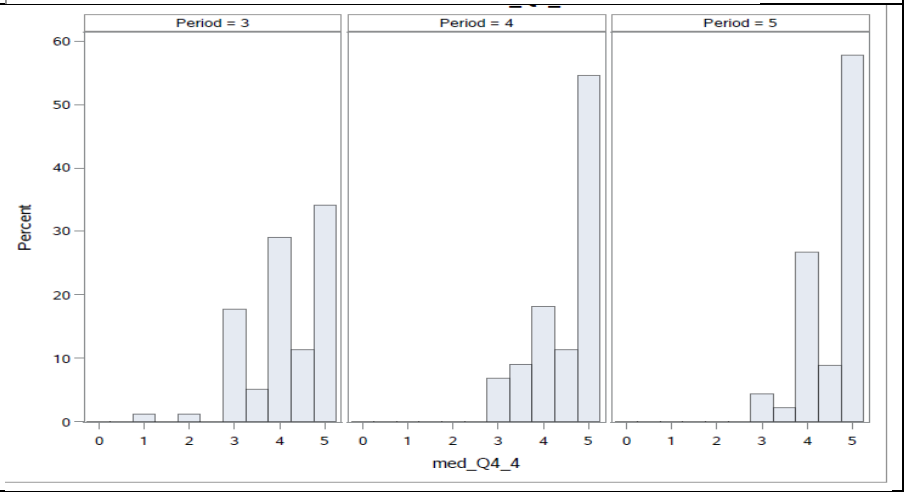
ID[a]	Outcomes[b]	p value[c]	Histogram[d]
Q4_1	In delis of high *L. monocytogenes* risk, employees reported to have greater commitment to food safety program during follow-up than immediately before deep clean (p_{adj}=0.0165).	0.0038	

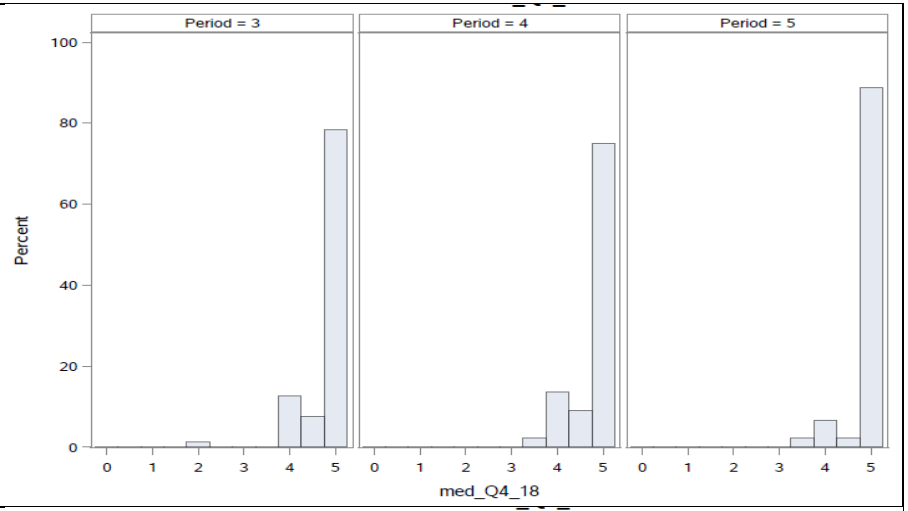
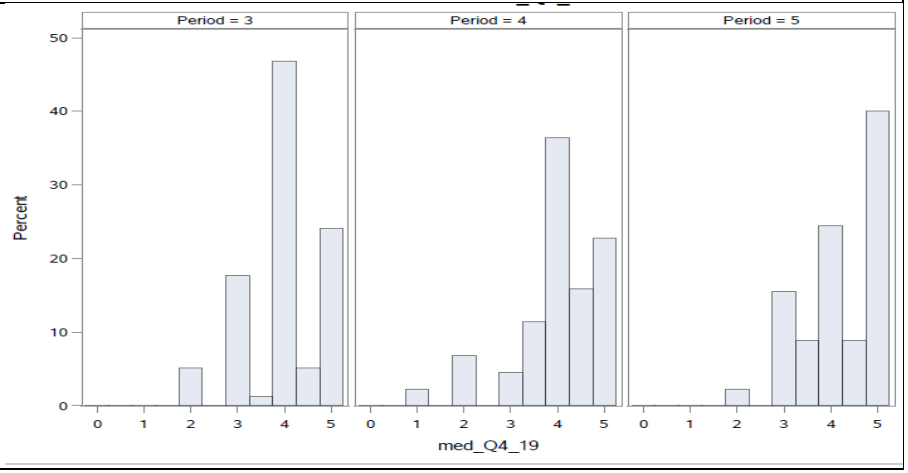
Q4_5	In delis of high *L. monocytogenes* risk, employees reported more likely to follow all food safety rules even if no one was looking during follow-up than immediately before deep clean (p_{adj}=0.0367).	0.0049	

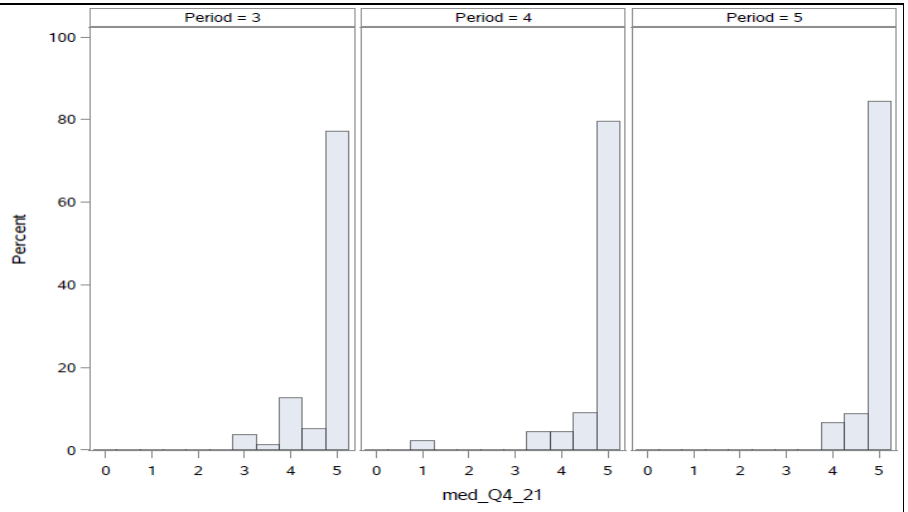
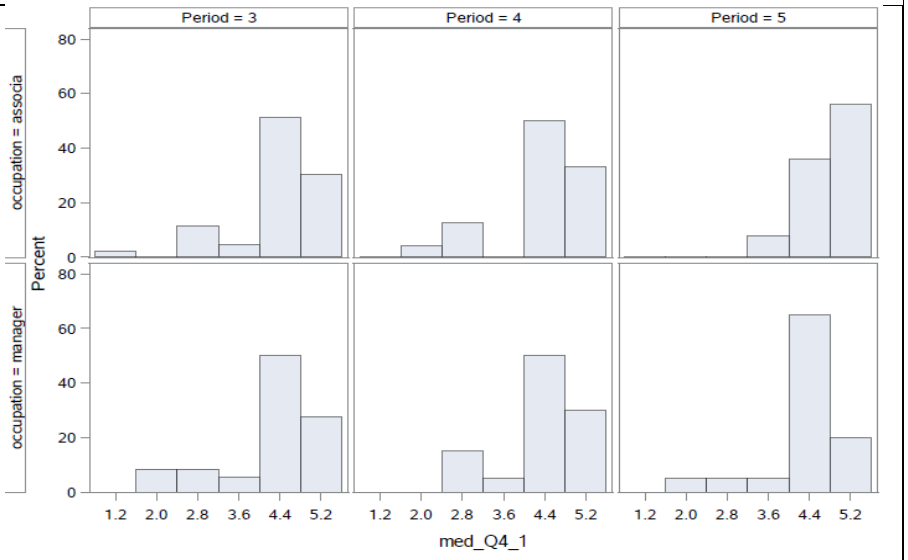
[a] All survey questions that were significantly correlated with the interaction between *L. monocytogenes* contamination risk and study period were listed with p<0.05, both questions are under "organizational climate" factor from principal component analysis;
[b] Context of the significant effects based on correlation analysis, Bonferroni adjustment was applied for multiple comparisons;
[c] Unadjusted overall p-values of each significant variables (p<0.05);
[d] Survey response distribution by period (in column) and *L. monocytogenes* risk (in rows) among the sampled delis, with "intervention=Y" designated to high *L. monocytogenes* contamination risk, "intervention=N" low risk, "period=3" immediately before deep clean, "period=4" immediately after deep clean, and "period=5" six-month follow-up, higher value in the Likert-scale survey response meaning more agreeable to the statement.

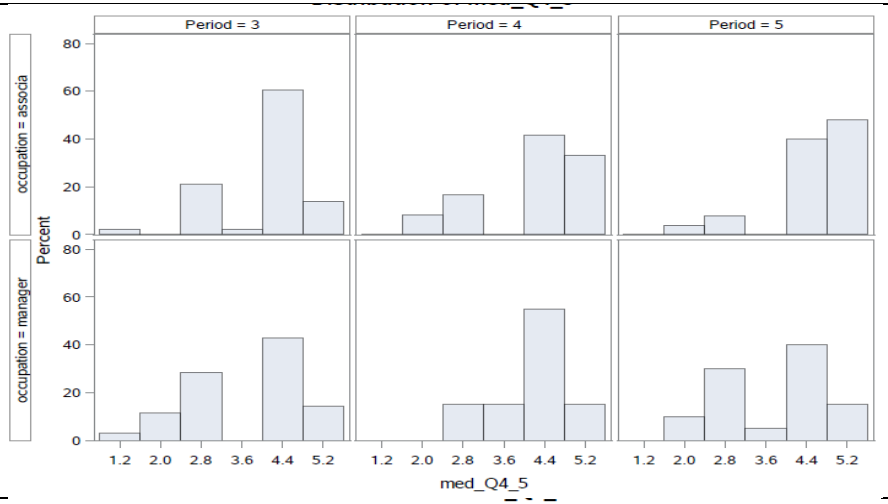
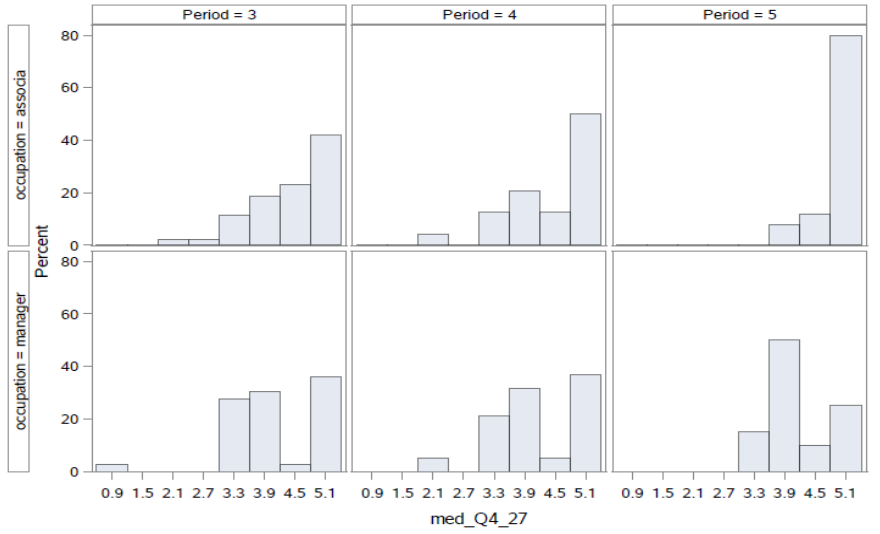
APPENDIX K. SURVEY VARIABLES THAT WERE SIGNIFICANTLY CORRELATED WITH DEEP CLEAN INTERVENTION, OCCUPATION STATUS, L. MONOCYTOGENES PREVALENCE, AND THEIR INTERACTIONS

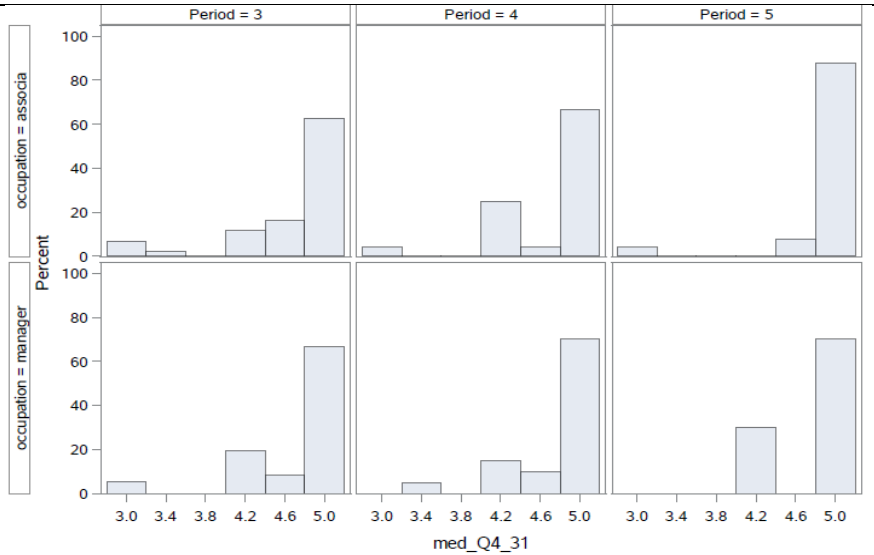
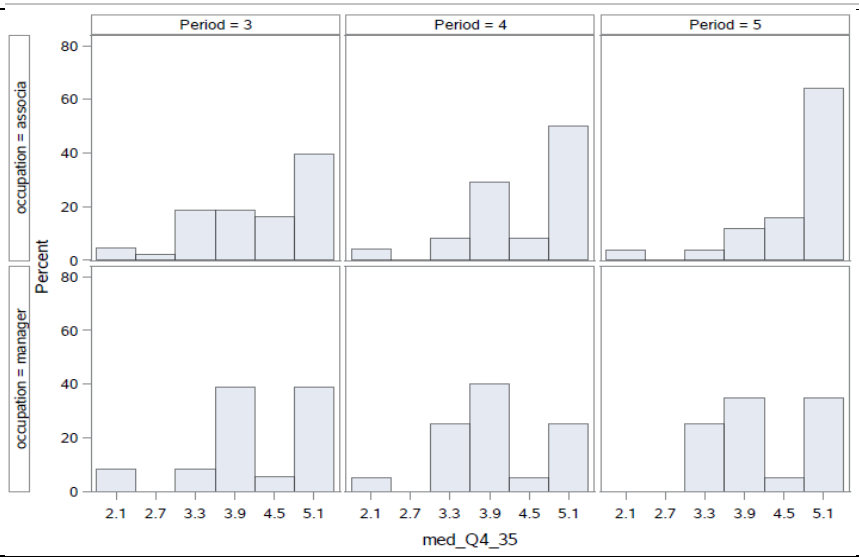
ID[a]	Effect[b]	Outcomes[c]	p value[d]	Visualization[e]
Q4_13_rc	Pct_LM	"Management sometimes encourage employees to do things that are against the food safety rules": Mixed results.	0.0415	

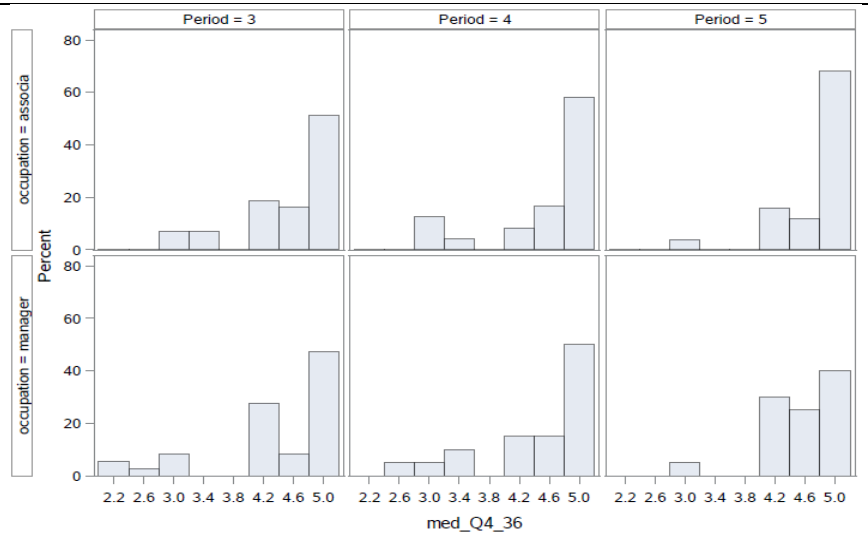
Q5_2		"Employees at this restaurant follow the food safety rules": Mixed results.	0.0171	
Q4_4	Period	Employees reported more likely to tell a manager when a food safety problem happened immediately after deep clean, than immediately before deep clean (p_{adj}=0.0265).	0.0433	

Q4_18†		Participants were more likely to agree that "I still wash my hands as much as I should when it is busy" immediately after deep clean, than immediately before deep clean (p_{adj}=0.0294).	0.0490	
Q4_19	Period	"Management asks for help from employees to improve our food safety program": Nature of effect is unclear.	0.0304	

Q4_21†		Participants were more likely to agree that "I believe it is important for me to follow all the food safety rules, not just the most important ones" immediately after deep clean, than immediately before deep clean (p_{adj}=0.0063).	0.0122	
Q4_1	Occupation*Period	"Employees are committed to the food safety program": Not estimable.	0.0409	

Q4_5		"Even if no one was looking, employees would follow all the food safety rules": Not estimable.	0.0383	
Q4_27	Occupation*Period	"Employees receive the proper training to follow the food safety rules": Not estimable.	0.0244	

Q4_31		"Management believes that food safety is very important": Not estimable.	0.0424	
Q4_35	Occupation*Period	"Management provides adequate-tools for training and/or education for food safety": Not estimable.	0.0046	

Q4_36		"The organization learns and makes changes when mistakes are found in food safety": Not estimable.	0.0157	

[a] All survey questions that were significant in the analysis correlating with *L. monocytogenes* prevalence (in percentage) were listed with $p<0.05$, [†] designated to the question under "individual's behavior" factor from principal component analysis, all else questions are under "organizational climate" factor;

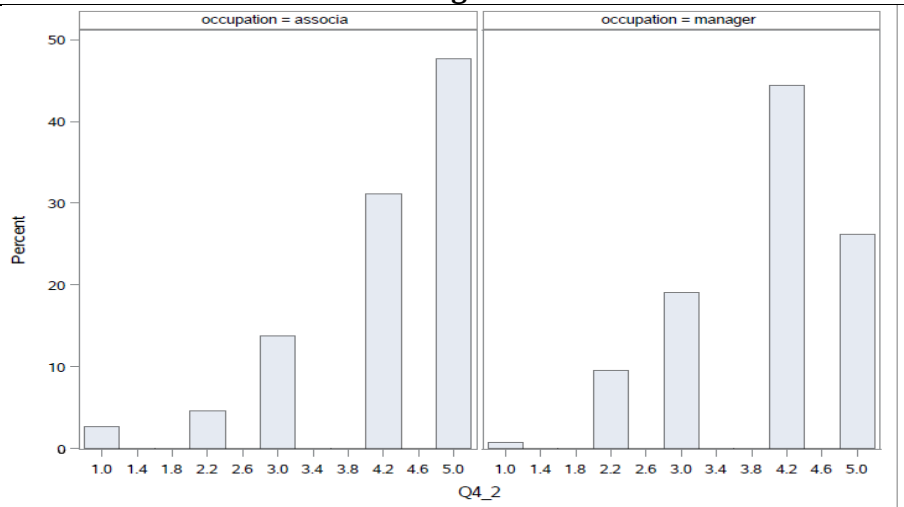
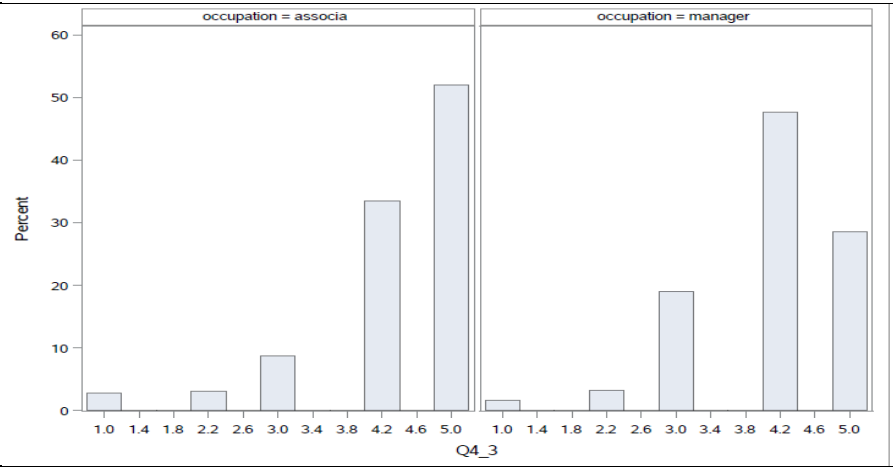
[b] Significant effect corresponding to the questions;

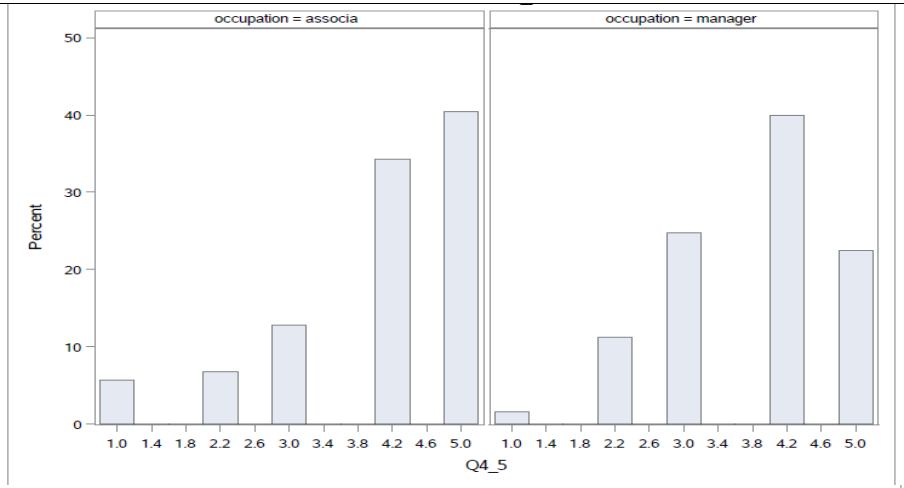
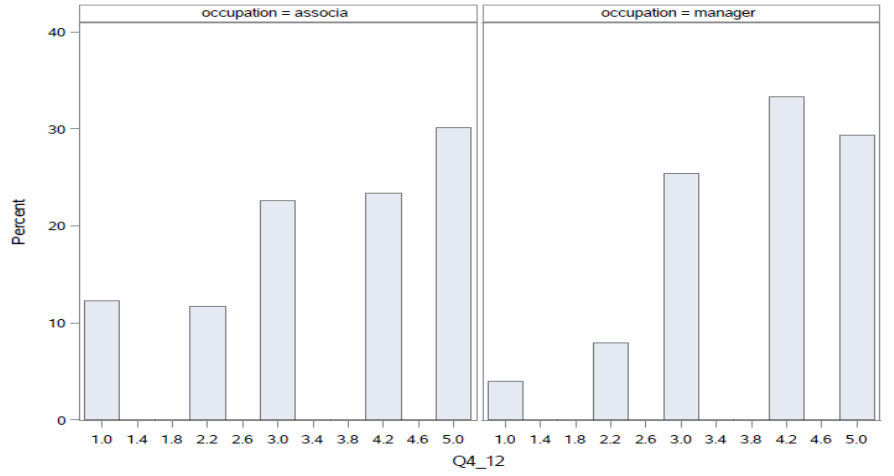
[c] Context of the significant effects based on correlation analysis, Bonferroni adjustment was applied for multiple comparison;

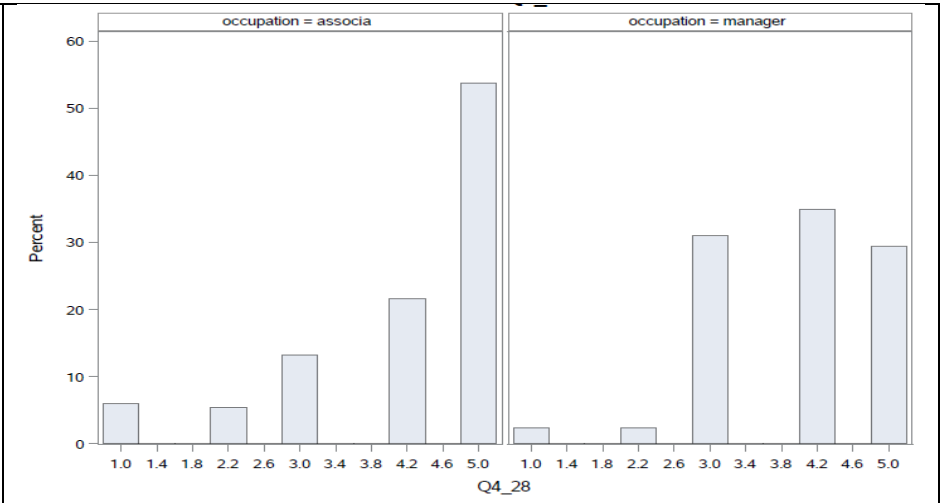
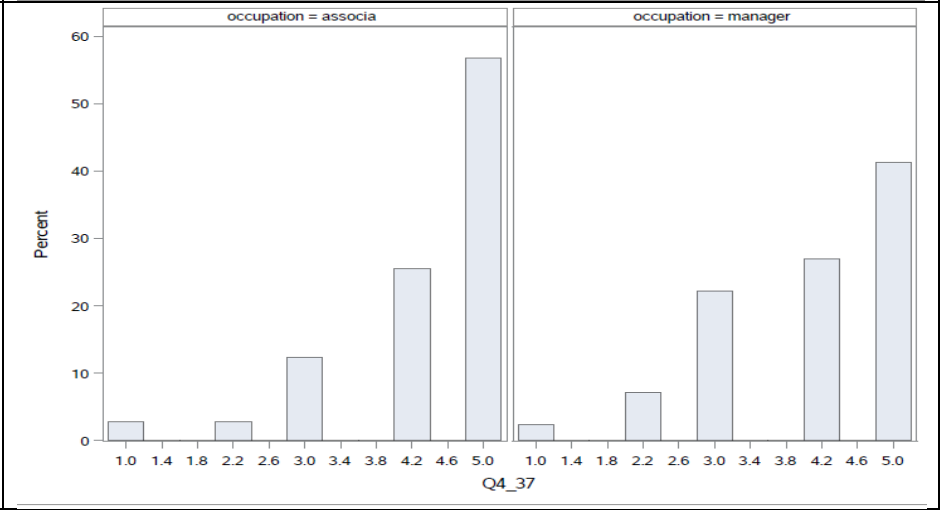
[d] Unadjusted p-values of each significant variables ($p<0.05$);

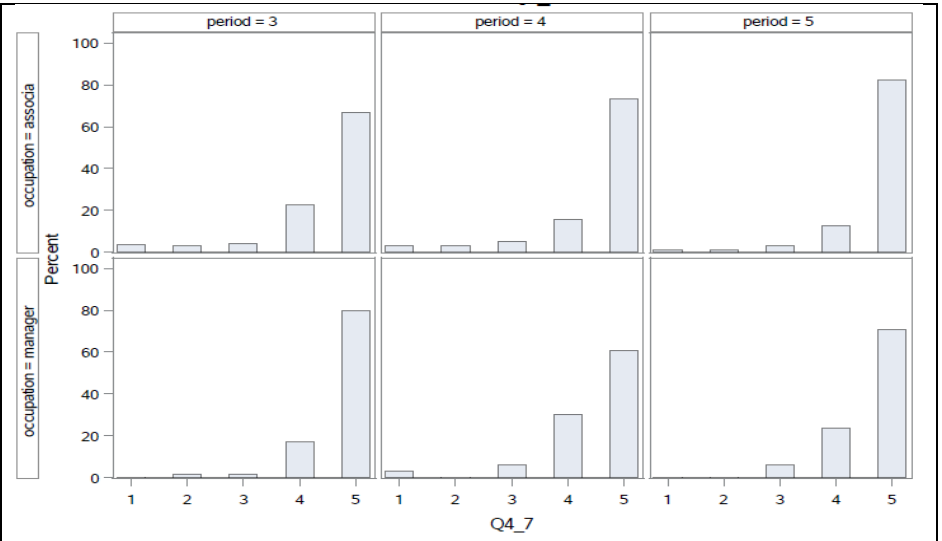
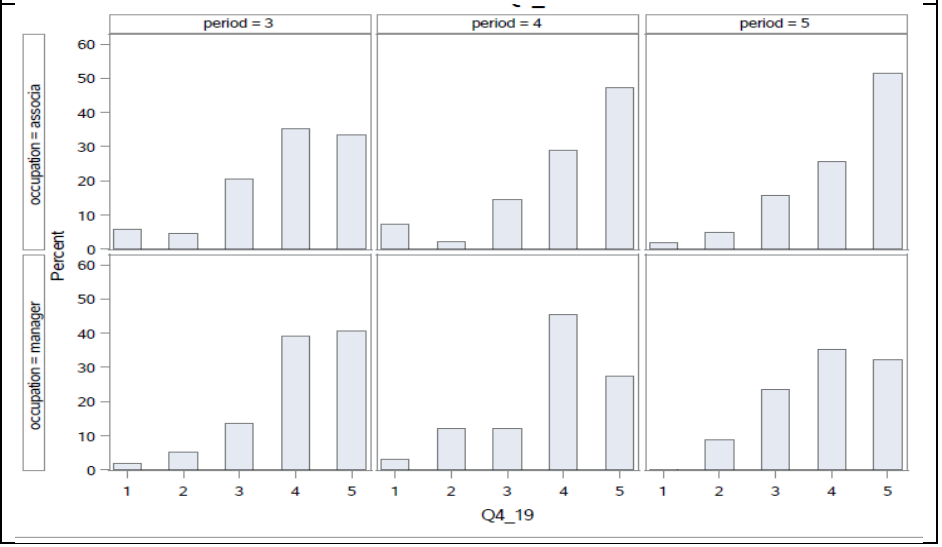
[e] Survey response distribution, with "pct_LM" designated to *L. monocytogenes* prevalence in deli environments in percentage, "period=3" immediately before deep clean, "period=4" immediately after deep clean, "period=5" 6-month follow-up; higher value in the Likert-scale survey response meaning more agreeable to the statement.

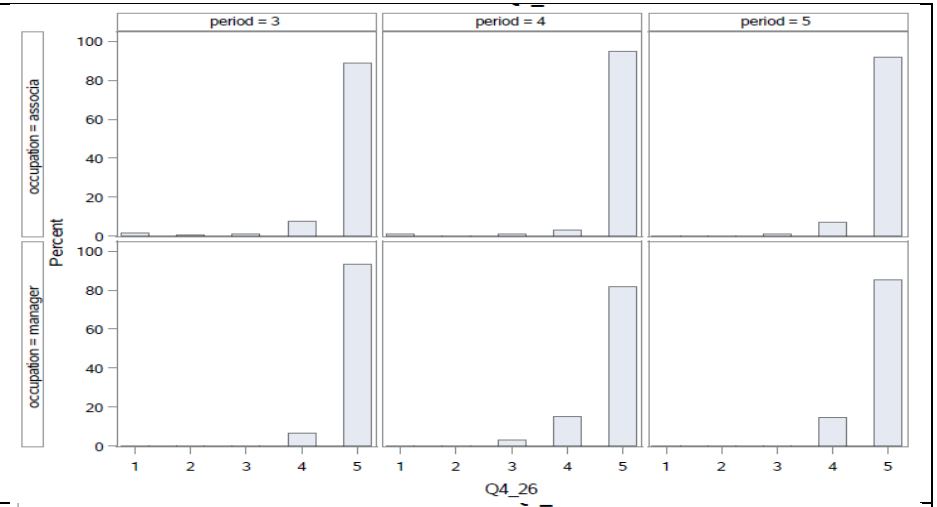
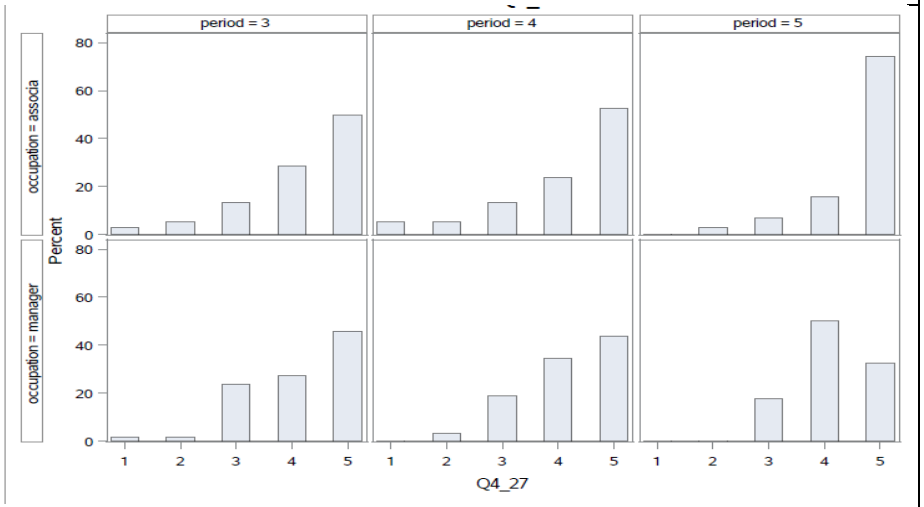
APPENDIX L. DIFFERENCES IN SURVEY RESPONSE BETWEEN DELI ASSOCIATES AND MANAGERS

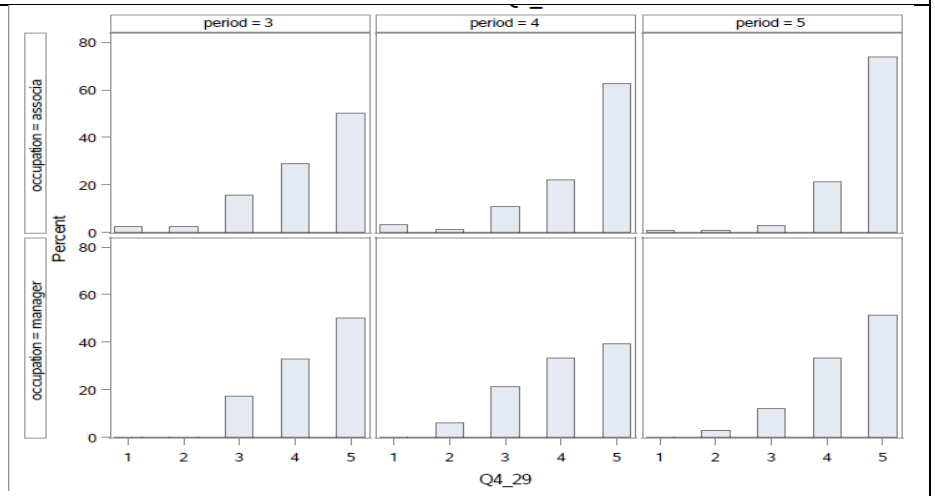
ID[a]	Effect[b]	Outcomes[c]	p value[d]	Histogram[e]
Q4_2	Occupation	Associates reported "employees more likely to encourage each other to follow food safety rules" than their managers did.	0.0168	
Q4_3		Associates reported "employees more likely to take responsibility for proper food handling in their work areas" than their managers did.	0.0129	

Q4_5	Occupation	Associates reported "employees were more likely to follow all the food safety rules even if no one was looking" than their managers did.	0.0200	
Q4_12		Managers reported "management more likely to praise employees who pay special attention to food safety" than their associates did.	0.0317	

Q4_28	Occupation	Associates reported "new employees more likely to receive all training they needed to perform their jobs according to food safety rules" than their managers did.	0.0076	
Q4_37		Associates reported "equipment more likely to be designed for proper cleaning" than their managers did.	0.0127	

Q4_7	Occupation*Period	"Management is committed to serving safe food": Nature of effect unclear.	0.0385	
Q4_19		"Management asks for help from employees to improve our food safety program": Nature of effect unclear.	0.0376	

Q4_26†	Occupation*Period	"I know why I should change my gloves to protect the food from contamination": Nature of effect unclear.	0.0489	
Q4_27		Associates were more likely to agree that "employees receive the proper training to follow the food safety rules" during follow-up than immediately before deep clean (p_{adj}=0.0001). During follow-up, associates were more likely to agree that "employees receive the proper training to follow	0.0125	

		the food safety rules" than managers did (p_{adj}=0.0078).		
Q4_29	Occupation*Period	Associates were more likely to agree that "food safety training gives us the necessary skills and/or knowledge to follow the food safety rules" during follow-up than immediately before deep clean (p_{adj}=0.0007).	0.0342	

[a] All survey questions that were reported having significant difference between associates and managers were listed with p<0.05, † designated to the question under "individual's behavior" factor from principal component analysis, all else questions are under "organizational climate" factor;

[b] Significant effect corresponding to the questions;

[c] Context of the significant effects based on correlation analysis, Bonferroni adjustment was applied for multiple comparisons for effect "occupation*period";

[d] Unadjusted p-values of each significant variables (p<0.05);

[e] Survey response distribution by occupation and period (where applicable), with "period=3" designated to immediately before deep clean, "period=4" immediately after deep clean, "period=5" 6-month follow-up; higher value in the Likert-scale survey response meaning more agreeable to the statement.

APPENDIX M. RETAIL PRODUCE INFRASTRUCTURE, SANITATION AND MANAGEMENT SURVEY

Q1.1 The purpose of this research is to better understand the cleaning and sanitation challenges you and your associates face each day. Our goal is to develop practical, efficient, and safe cleaning and sanitation programs to help continuously improve food safety in retail produce areas. As a part of our ongoing study, we have developed the following survey to gather information on daily, weekly, and monthly operations and practices in each of the stores participating in this study. We are confident that you, as a manager, are best able to describe day-to-day practices as well as the types of equipment currently in your store. The results from this survey will be blinded (i.e. made anonymous) and will not impact your performance review, employment status, or relationship with your employer in any way. We ask that you answer all questions honestly and to the best of your ability as your responses will help guide future training programs, equipment investments, and recommended cleaning and sanitation programs.

We thank you for your time and support of our study; it would not be possible without you.

Q2.1 Do produce area employees work in other departments during a single shift?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Do produce area employees work in other departments during a single shift? Yes Is Selected

Q2.2 Which department(s) do the produce area employees work in? Please check ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Groery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q2.3 Do temporary and/or short-term employees undergo the same set and same amount of training regarding food handling and processing, personal hygiene, cleaning and sanitizing procedure as the full-time, long-term employees before they start working?

- ❍ Yes (1)
- ❍ No (2)

Q2.4 If produce area employees are ill (e.g., vomiting, nausea, diarrhea), are they allowed and paid for their sick leave after notifying the manager?

- ❍ Yes, employees are paid full wage (1)
- ❍ Yes, employees are paid partial wage (2)
- ❍ No, employees are not paid (3)
- ❍ Not applicable, employees are not encouraged to take sick leave (4)

Q2.5 During new employee orientation, what procedure(s) are taken to aid employees' understanding in food safety and food safety conduct? Please select ALL that apply.

- ❑ Relevant handouts are given (1)
- ❑ Specific examples and detailed explanations are talked through (2)
- ❑ Demonstrations of food safety conduct and personal hygiene are given (3)
- ❑ Questions and concerns about food safety from the employees are encouraged and addressed (4)
- ❑ Other methods are used to ensure employees' understanding (5)
- ❑ No methods are used to ensure employees' understanding (6)
- ❑ There is no orientation (7)

Q2.6 Are employees in produce area required to take Super Safe Mark and Serve Safe training before they start working?

- ❍ Yes (1)
- ❍ No (2)

Q2.7 How often are employees re-trained?

- ❍ Once every 2-3 years (1)
- ❍ Once every 4-5 years (2)
- ❍ Less than once per 5 years (3)
- ❍ Not applicable, employees are not retained (4)
- ❍ Not applicable, employees are not trained (5)

Q2.8 Management method actively promotes food safety behavior among produce area employees via:Please check ALL that apply.

- ❑ Selecting role models from employees who best follow food safety rules (1)
- ❑ Issuing paid or partially paid sick leave to employees (2)
- ❑ Encouraging employees to ask questions and voice concerns regarding proper food conduct and food safety rules at all time (3)
- ❑ Requiring employees to report their health conditions and symptoms contracted (4)
- ❑ Encouraging employees to help each other with understanding and practicing food safety culture (5)
- ❑ Other methods are taken (6)
- ❑ No methods are taken (7)

Q2.9 Have produce cases been replaced and/or repaired in last 5 years?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q2.10 Has the produce area undergone a major renovation (e.g., wall construction, complete floor replacement) in last 5 years?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q2.11 Do workers from other departments walk through the produce area during their work?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Do workers from other departments walk through the produce area during their work? Yes Is Selected

Q2.12 Which departments are the workers from?

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q2.13 Do produce area employees walk through other departments during their work?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Do produce area employees walk through other departments during their work? Yes Is Selected

Q2.14 Which departments do they walk through? Please check ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q2.15 How many hours a day are dedicated to cleaning tasks in the produce prepare area during operation?

- ❍ 1 hours (1)
- ❍ 2 hours (2)
- ❍ 3 hours (3)
- ❍ 4 hours (4)
- ❍ 5 hours (5)

Q2.16 Is produce being processed and/or exposed when the cleaning tasks are performed during operation?

- ❍ Yes (1)
- ❍ Maybe (2)
- ❍ No (3)
- ❍ I don't know (4)

Q2.17 Are designated disposable gloves used only for serving food in produce area?

- ❍ Yes (1)
- ❍ No, disposable gloves are shared with other departments (2)
- ❍ No, there are no disposable gloves (3)

Q2.18 Are disposable gloves changed after touching non-food-contact surfaces (e.g., cart handles, hand wash sink basin, drain cover, etc.)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)
- ❍ Not applicable (4)

Q2.19 Is the produce retail area cleaned in a specific order at the end of the day after it has closed?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q2.20 Is the produce prepare area cleaned in a specific order at the end of the day after it has closed?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q2.21 When are floor surfaces in the produce retail area cleaned relative to other areas in the produce retail area?

- ❍ First (1)
- ❍ Concurrently with other equipment (2)
- ❍ Last (3)
- ❍ I don't know (4)
- ❍ Not applicable, cleaning tasks do not follow a specific order (5)
- ❍ They are not cleaned (6)

Q2.22 When are floor surfaces in the produce prepare area cleaned relative to other areas in the produce prepare area?

- ❍ First (1)
- ❍ Concurrently with other equipment (2)
- ❍ Last (3)
- ❍ I don't know (4)
- ❍ Not applicable, cleaning tasks do not follow a specific order (5)
- ❍ They are not cleaned (6)

Q2.23 Are there written documents of Sanitation Standard Operating Procedures (SSOPs) dedicated for the produce area?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Are there written documents of Sanitation Standard Operating Procedures (SSOPs) dedicated for the... Yes Is Selected

Q2.24 Are records of past cleaning and sanitizing kept as a part of SSOPs?

- ❍ Yes (1)
- ❍ No (2)

Q2.25 Are food contact surfaces routinely tested for major disease-causing bacteria derived from food and/or other types of contamination?

- ❍ Yes, please specify frequency: (1) _____
- ❍ No (2)
- ❍ I don't know (3)

Q2.26 Are nonfood contact surfaces routinely tested for major disease-causing bacteria derived from food and/or other types of contamination?

- ❍ Yes, please specify frequency: (1) _____
- ❍ No (2)
- ❍ I don't know (3)

Q2.27 Is a raw meat or seafood department adjacent to the produce area?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Is a raw meat or seafood department adjacent to the produce area? Yes Is Selected

Q2.28 Approximately how far is the raw meat or seafood department from the produce area?

- ❍ <5 feet (1)
- ❍ 5-10 feet (2)
- ❍ 10-15 feet (3)
- ❍ 15-20 feet (4)
- ❍ 20-25 feet (5)
- ❍ > 25 feet (6)

Q2.29 How often are used squeegee heads (used to clean floor) replaced with clean ones?

- ❍ Once every week (1)
- ❍ Once every 2-3 weeks (2)
- ❍ Once per month (3)
- ❍ Once every 2 months (4)
- ❍ Less than once every 2 months (5)
- ❍ They are not replaced (6)

Q2.30 Are squeegees shared between produce area and other department?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Are squeegees shared between produce area and other department? Yes Is Selected

Q2.31 Which department(s) is sharing the squeegees? Please select ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q2.32 Which part(s) of the produce cases do you find difficult to clean? Please check ALL that apply.

- ❑ Upper shelf level holding misted produce (1)
- ❑ Upper shelf level holding dry produce (2)
- ❑ Bottom shelf level holding misted produce (3)
- ❑ Bottom shelf level holding dry produce (4)
- ❑ Drains and drain covers on the floor (5)
- ❑ Floor under the sink (6)
- ❑ Floor-wall junction (7)
- ❑ Rack cart shelves (8)
- ❑ Mister nozzles (9)
- ❑ Handwashing sink basin (10)
- ❑ Crisping sink and/or 3-compartment sink (11)
- ❑ Case shelves holding misted produce (12)
- ❑ Case shelves used for moving produce (13)
- ❑ Other, please specify: (14) _____
- ❑ Not applicable (15)

Q2.33 Is the floor-wall junction coved (curved and sealed) in the produce preparing area?

- ❍ Yes (1)
- ❍ No (2)

Q2.34 How do you manage standing water? Please check ALL the apply.

- ❑ Wet vac (1)
- ❑ Water snake (2)
- ❑ Towel and mop (3)
- ❑ Squeegee (4)
- ❑ Other, please specify: (5) _____
- ❑ Nothing is done (6)
- ❑ I don't know (7)

Q2.35 What type(s) of drain is present in the produce area? Please check ALL that apply.

- ❑ Floor drain (or catch basin) (1)
- ❑ Trench drain with automatic flushing (2)
- ❑ Trench drain without automatic flushing (3)
- ❑ Other, please specify: (4) _____
- ❑ None are present (5)

Q2.36 Does water pool near the drain on the floor in produce prepare area?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q2.37 Does water pool near misted produce case drain cover in produce retail area?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q3.1 How many shifts are scheduled per day in your produce area?

- ❍ 1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ Greater than 5 (6)

Q3.2 Approximately how many employees, on average, work during one single shift in the produce area (both preparing area and retail area)?

- ❍ 1 to 2 (1)
- ❍ 3 to 4 (2)
- ❍ 5 to 6 (3)
- ❍ 7 to 8 (4)
- ❍ 9 to 10 (5)
- ❍ Greater than 10 (6)

Q3.3 What is the total number of employees working in the produce area (both preparing area and retail area) among all shifts?

- ❍ 3 to 4 (1)
- ❍ 5 to 6 (2)
- ❍ 7 to 8 (3)
- ❍ 9 to 10 (4)
- ❍ 11 to 12 (5)
- ❍ 13 to 14 (6)
- ❍ Greater than 14 (7)

Q3.4 Does the number of employees working in the produce area vary by season (e.g., holidays, summer)?

- ❍ Yes (1)
- ❍ No (2)

Q3.5 How many hours per day, on average, does produce retail area serve customers?

- ❍ Shorter than 10 hours (1)
- ❍ 10 to 12 hours (2)
- ❍ 13 to 15 hours (3)
- ❍ 16 to 18 hours (4)
- ❍ Longer than 18 hours (5)

Q3.6 How many hours per day, on average, does produce prepare area serve customers?

- ❍ Shorter than 10 hours (1)
- ❍ 10 to 12 hours (2)
- ❍ 13 to 15 hours (3)
- ❍ 16 to 18 hours (4)
- ❍ Longer than 18 hours (5)

Q3.7 Do employees wear clean outer clothing dedicated only to the produce area and no other purposes (e.g. not in the locker room outside the produce area; not on their way to work, etc.)?

- ❍ Yes (1)
- ❍ No, the outer clothing may not be clean (2)
- ❍ No, there is no outer clothing (3)
- ❍ I don't know (4)

Q3.8 Are there signs reminding employees of handwashing in the bathrooms?

- ❍ Yes (1)
- ❍ No (2)

Q3.9 A written Employee Health Policy is established for all employees in the produce area, which claims that employees are responsible for reporting any of their symptoms and/or diseases that can potentially result in contamination of foods.

- ❍ True (1)
- ❍ False (2)

Q3.10 What is the approximate age of the building?

- ❍ Shorter than 5 years (1)
- ❍ 5 to 10 years (2)
- ❍ 10 to 15 years (3)
- ❍ 15 to 20 years (4)
- ❍ 20 to 25 years (5)
- ❍ I don't know (6)

Q3.11 Has equipment used for processing value-added products been replaced and repaired in last 5 years?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Display This Question:
If Has equipment used for processing value-added products been replaced and repaired in last 5 years? Yes Is Selected

Q3.12 What value-added products are made in the produce area? Please check ALL that apply.

- ❑ Juices (1)
- ❑ Nut butters (2)
- ❑ Guacamole (3)
- ❑ Others, please specify: (4) _____

Q3.13 Do produce area employees have designated cleaning tasks?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Do produce area employees have designated cleaning tasks? Yes Is Selected

Q3.14 In which department(s) do the produce area employees perform the cleaning tasks? Please check ALL that apply.

- ❑ Within the produce area (1)
- ❑ Bakery (2)
- ❑ Dairy (3)
- ❑ Deli (4)
- ❑ Grocery (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q3.15 How many hours a day are dedicated to cleaning tasks at the end of the day after the produce prepare area has closed?

- ❍ 1 hour (1)
- ❍ 2 hours (2)
- ❍ 3 hours (3)
- ❍ 4 hours (4)
- ❍ 5 hours (5)

Q3.16 The produce retail area is cleaned at the end of daily operation by: Please check ALL that apply.

- ❑ Produce area employees (1)
- ❑ Designated cleaning crew (2)
- ❑ Third party cleaning service (3)
- ❑ Other, please specify: (4) _____

Q3.17 The produce prepare area is cleaned at the end of daily operation by: Please check ALL that apply.

- ❑ Produce area employees (1)
- ❑ Designated cleaning crew (2)
- ❑ Third party cleaning service (3)
- ❑ Other, please specify: (4) _____

Q3.18 How often, on average, do associates change gloves?

- ❍ After each type of produce is handled (1)
- ❍ Once every hour (2)
- ❍ Once every 2-4 hours (3)
- ❍ Every time before leaving the produce area (4)
- ❍ Once every shift (5)
- ❍ I don't know (6)
- ❍ Associates do not wear gloves (7)

Q3.19 SSOP is an important reference source to initiate change in management and practice, in order to improve the outcome of sanitation.

- ❍ True (1)
- ❍ False (2)
- ❍ I'm not sure (3)
- ❍ Not applicable, no SSOP is present (4)

Q3.20 What type of flooring material is present in the produce retail area?

- ❍ Ceramic tile and grout (1)
- ❍ Epoxy/synthetic floor (2)
- ❍ Cement (3)
- ❍ Carpet (not anti-slip mat) (4)
- ❍ Other, please specify: (5) _____
- ❍ I don't know (6)

Q3.21 What type of flooring material is present in the produce prepare area?

- ❍ Ceramic tile and grout (1)
- ❍ Epoxy/synthetic floor (2)
- ❍ Cement (3)
- ❍ Carpet (not anti-slip mat) (4)
- ❍ Other, please specify: (5) _____
- ❍ I don't know (6)

Q3.22 Equipment and facility layout are designed to prevent drippage and condensation formation.

- ❍ True (1)
- ❍ False (2)
- ❍ I'm not sure (3)

Q3.23 Is the single-basin non-handwashing sink shared between produce area and other departments?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, sink not present (3)

Display This Question:
If Is the single-basin non-handwashing sink shared between produce area and other departments? Yes Is Selected

Q3.24 What department(s) is sharing the sink? Please select ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q3.25 Is produce handled and/or opened in the single-basin non-handwashing sink?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, sink not present (3)

Q3.26 Is the handwashing sink shared between produce area and other department?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, sink not present (3)

Display This Question:
If Is the handwashing sink shared between produce area and other department? Yes Is Selected

Q3.27 What department(s) is sharing the sink? Please select ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q3.28 Is produce handled and/or opened in the handwashing sink?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, sink not present (3)

Q3.29 Is the three-basin sink (or equivalent such as a two-basin sink) shared between produce area and other departments?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, sink not present (3)

Display This Question:
If Is the three-basin sink (or equivalent such as a two-basin sink) shared between produce area and... Yes Is Selected

Q3.30 What department(s) is sharing the sink? Please select ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q3.31 Are wheeled carts shared between produce area and other departments?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, wheeled carts not present (3)

Display This Question:
If Are wheeled carts shared between produce area and other departments? Yes Is Selected

Q3.32 What department(s) is sharing the wheeled carts? Please select ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q3.33 Are cutting boards shared between produce area and other department?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not applicable, cutting boards not present (3)

Display This Question:
If Are cutting boards shared between produce area and other department? Yes Is Selected

Q3.34 What department(s) is sharing the cutting boards? Please select ALL that apply.

- ❑ Bakery (1)
- ❑ Dairy (2)
- ❑ Deli (3)
- ❑ Grocery (4)
- ❑ Prepared food (5)
- ❑ Raw meat (6)
- ❑ Seafood (7)
- ❑ Other, please specify: (8) _____

Q3.35 Which types of sanitizers are used on food contact surfaces (e.g., sink basin used for washing or crisping produce, shelves)? Please check ALL that apply.

- ❑ Bleach (1)
- ❑ Quaternary ammonium ("Quat") (2)
- ❑ Iodine (3)
- ❑ Other, please specify: (4) _____
- ❑ I don't know (5)
- ❑ None (6)

Display This Question:
If Which types of sanitizers are used on food contact surfaces (e.g., sink basin used for washing or... None Is Not Selected

Q3.36 What concentration of sanitizer(s) is used on food contact surfaces? Enter the answer as: "name of the sanitizer: concentration (ppm)", or "I don't know".

Q3.37 Are sanitizer concentrations for food contact surfaces verified (e.g., by test strip)?

- Yes (1)
- No, the sanitizer concentrations are not verified (2)
- I don't know if the sanitizer concentrations are verified or not (3)

Display This Question:
If Are sanitizer concentrations for food contact surfaces verified (e.g., by test strip)? Yes Is Selected

Q3.38 How often are the sanitizer concentrations verified?

- Once every week (1)
- Once every 2 weeks (2)
- Once per month (3)
- Less than once per month (4)
- I don't know (5)

Q4.1 How often is the floor of produce retail area cleaned?

- Once every 4 hours (1)
- Once daily (2)
- Once every 2-4 days (3)
- Once every 5=7 days (4)
- Once every 2 weeks (5)
- Once per month (6)
- Less than once per month (7)
- I don't know (8)

Q4.2 How often is the floor of produce prepare area cleaned?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)

Q4.3 Which sanitizing equipment is used on floors? Please check ALL that apply.

- ❑ Bleach (1)
- ❑ Quaternary ammonium (Quat) (2)
- ❑ Iodine (3)
- ❑ Hot water (about 171 °F/ 77 °C) (4)
- ❑ Other, please specify: (5) _____
- ❑ I don't know (6)
- ❑ None (7)

Display This Question:

If Which sanitizing methods are used on floors? Please check ALL that apply. None Is Not Selected

Q4.4 What concentration of sanitizer(s) is used on floors? Enter the answer as: "name of the sanitizer;concentration (ppm)", or "I don't know".

Q4.5 How often is the floor of produce retail area sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Not applicable, the floor is not sanitized (9)

Q4.6 How often is the floor of produce prepare area sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Not applicable, the floor is not sanitized (9)

Q4.7 What procedures are used to clean and sanitize the floor of produce retail area? Please check ALL that apply.

- ❑ Pressurized water (e.g., hose) (1)
- ❑ Scrub brushes (2)
- ❑ Mops (3)
- ❑ Spray-on sanitizer (liquid) (4)
- ❑ Spray-on sanitizer (foam) (5)
- ❑ Other (6)
- ❑ I don't know (7)

Q4.8 What procedures are used to clean and sanitize the floor of produce prepare area? Please check ALL that apply.

- ❑ Pressurized water (e.g., hose) (1)
- ❑ Scrub brushes (2)
- ❑ Mops (3)
- ❑ Spray-on sanitizer (liquid) (4)
- ❑ Spray-on sanitizer (foam) (5)
- ❑ Other (6)
- ❑ I don't know (7)

Q4.9 How often is the floor under the sinks cleaned and sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)

Q4.10 How often is the produce area cold room floor cleaned?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)

Q4.11 Which sanitizing equipment is used on produce area cold room floor? Please check ALL that apply

- ❑ Bleach (1)
- ❑ Quaternary ammonium (Quat) (2)
- ❑ Iodine (3)
- ❑ Hot water (about 171 °F/77 °C) (4)
- ❑ Other, please specify: (5) _____
- ❑ I don't know (6)
- ❑ None (7)

Display This Question:

If Which sanitizing methods are used on cold room floor? Please check ALL that apply None Is Not Selected

Q4.12 What concentration of sanitizer(s) is used on floors? Enter the answer as: "name of the sanitizer;concentration (ppm)", or "I don't know".

Q4.13 How often is the produce area cold room floor sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Not applicable, the floor is not sanitized (9)

Q4.14 How often are the drains in the produce retail area cleaned?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Not applicable, drain not present (9)

Q4.15 How often are the drains in the produce prepare area cleaned?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Not applicable, drain not present (9)

Q4.16 Which sanitizing equipment is used on the drains on the floor? Please check ALL that apply.

- ❑ Bleach (1)
- ❑ Quaternary ammonium ("Quat") (2)
- ❑ Iodine (3)
- ❑ Hot water (about 171 °F/77 °C) (7)
- ❑ Other, please specify: (4) _____
- ❑ I don't know (5)
- ❑ None (6)

Display This Question:

If Which sanitizing methods are used for the drains on the floor? Please check ALL that apply. None Is Not Selected

Q4.17 What concentration of sanitizer(s) is used for sanitizing the drains on the floor? Enter the answer as: "name of the sanitizer; concentration (ppm)", or "I don't know".

Q4.18 How often are the drains in the produce retail area sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Drains are not sanitized (9)
- ❍ Not applicable, drain not present (10)

Q4.19 How often are the drains in the produce prepare area sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Drains are not sanitized (9)
- ❍ Not applicable, drain not present (10)

Q4.20 What procedures are used to clean and sanitize drains on the floor in produce area? Please check ALL that apply.

- ❑ Scrub brushed (1)
- ❑ Designated cleaning tools (2)
- ❑ Designated drain cleaner (3)
- ❑ Pressurized water (e.g., hose) (4)
- ❑ Liquid sanitizer (5)
- ❑ Foam sanitizer (6)
- ❑ Anti-splash reagent, such as "splash guard" (7)
- ❑ Other (8)
- ❑ I don't know (9)

Q4.21 How often are the drains in produce area cold room cleaned?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Not applicable, drain not present (9)

Q4.22 How often are the drains in produce area cold room sanitized?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Drains are not sanitized (9)
- ❍ Not applicable, drain not present (10)

Q4.23 How often are cart shelves (used to move produce) in the produce area cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Cart shelves are not cleaned and sanitized (9)

Q4.24 How often are handles (or steering grips) of the cart in the produce area cleaned and sanitized? (Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Handles (or steering grips) are not cleaned and sanitized (9)

Q4.25 How often, on average, is conventional and organic produce case drain cover (where water drains from the bottom shelf to the drain below) cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)
- ❍ Case drain cover is not cleaned and sanitized (9)

Q4.26 How often are food contact surfaces of produce retail case cleaned?

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ I don't know (8)

Q4.27 How often is the produce retail case taken apart and cleaned down to the coils?

- ❍ Once daily (1)
- ❍ Once every 2-4 days (2)
- ❍ Once every 5-7 days (3)
- ❍ Once every 2 weeks (4)
- ❍ Once per month (5)
- ❍ Once every 2 months (6)
- ❍ Less than once every 2 months (7)
- ❍ I don't know (8)

Q4.28 How is the produce retail case cleaned down to the coils?

- ❍ All at once with all food products removed (1)
- ❍ With products remaining in sections separate from the section being cleaned (2)
- ❍ Other (3)
- ❍ I don't know (4)

Q4.29 How often are produce retail case handles cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Case handles are not cleaned and sanitized (8)
- ❍ I don't know (9)

Q4.30 How often is the single-basin non-handwashing sink cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Sink is not cleaned and sanitized (8)
- ❍ I don't know (9)
- ❍ Sink not present (10)

Q4.31 How often is handwashing sink in the produce area cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Sink is not cleaned and sanitized (8)
- ❍ I don't know (9)
- ❍ Sink not present (10)

Q4.32 How often is the three-basin sink (or equivalent such as two-basin sink) in the produce area cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Sink is not cleaned and sanitized (8)
- ❍ I don't know (9)
- ❍ Sink not present (10)

Q4.33 How often are wheeled carts used in the produce area cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Wheeled carts are not cleaned and sanitized (8)
- ❍ I don't know (9)

Q4.34 How often are scale surfaces (food contact surface) are cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Scale surfaces are not cleaned and sanitized (8)
- ❍ I don't know (9)

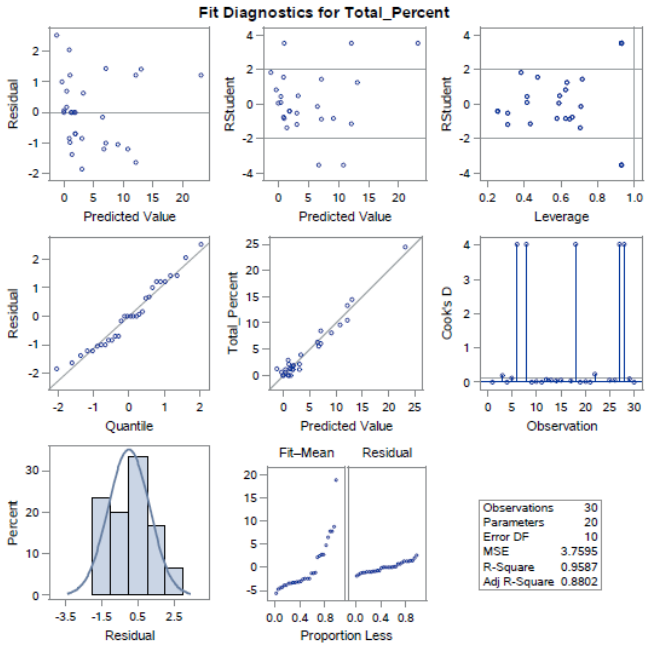
Q4.35 How often are the produce area cold room racks cleaned and sanitized?(Common equipment of sanitizing includes: bleach, Quat, iodine, hot water (171 °F/77 °C), steam)

- ❍ Once every 4 hours (1)
- ❍ Once daily (2)
- ❍ Once every 2-4 days (3)
- ❍ Once every 5-7 days (4)
- ❍ Once every 2 weeks (5)
- ❍ Once per month (6)
- ❍ Less than once per month (7)
- ❍ Cold room racks are not cleaned and sanitized (8)
- ❍ I don't know (9)

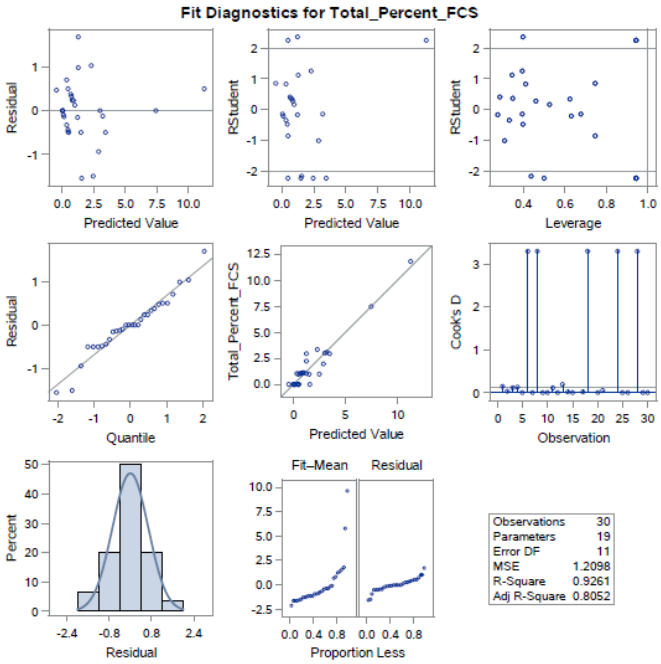
APPENDIX N. GENERAL LINEAR REGRESSION FIT DIAGNOSTICS

General linear regression (Proc GLM) fit diagnostics for *L. monocytogenes* prevalence on A) all surfaces (both FCS and NFCS), B) FCS, and C) NFCS.

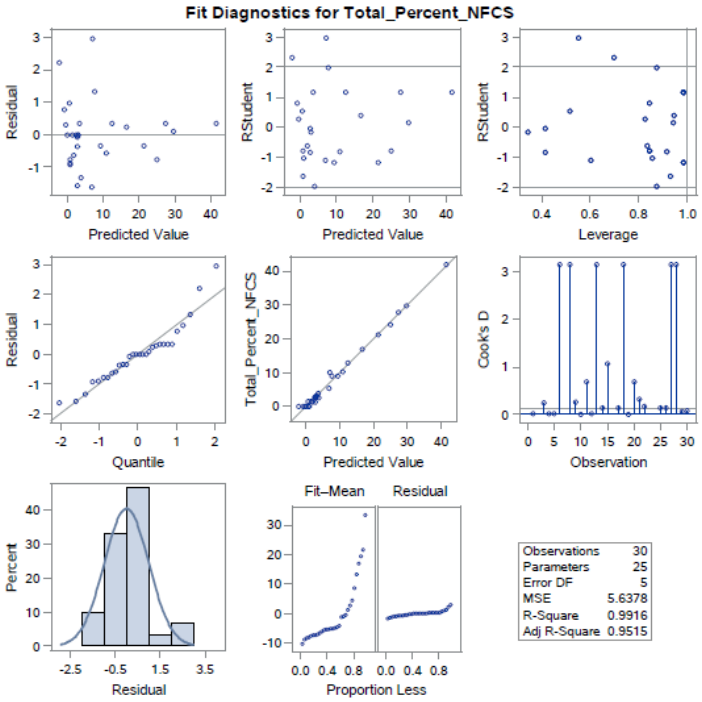
A).



B).



C).


Fit Diagnostics for Total_Percent_NFCS
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
Total_Percent_NFCS
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 30
Parameters 25
Error DF 5
MSE 5.6378
R-Square 0.9916
Adj R-Square 0.9515