Master of Public Health

Integrative Learning Experience Report

FROM FOOD SAMPLING LOCATIONS TO PEDAGOGY: EXPLORING GEOGRAPHIC DIETARY VARIATIONS AND GAMIFIED LEARNING IN HEALTH ECONOMICS

by

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MASTER OF PUBLIC HEALTH

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Summary/Abstract

This Integrated Learning Experience explores two distinct topics, yet both are related to public health initiatives. The first topic involves food and beverage analyte testing through the Food and Drug Administration's Total Diet Study (TDS) program. The TDS assesses nutrients and contaminants in packaged food and beverage products that are commonly consumed in the United States of America. The foods and beverages were collected from a geographic region across USA. Analyte levels were statistically evaluated using ANOVA and Limit of Detection with the aim to determine whether sampling frequency and location could be reduced without compromising data reliability. Results indicated that regional variations were minimal except for bottled water. The limit of detection analyses indicated that most samples were at or near 0 for contaminants.

A gamified leaning experience using cost minimization analysis was created for a healthcare economics graduate classroom. This escape room assignment allows students to work together to cut operational costs for a rural hospital system, specifically looking at chronic care follow-up appointments using Telehealth vs. traditional in-person appointments. The students calculate the lower cost option and then present the option to the Board of Directors for approval using a multimedia presentation. Together, these two projects examine important areas of public health education including food safety surveillance and healthcare cost management.

Subject Keywords: Total Diet Study, Cost Minimization Analysis, Healthcare Economics Education, Food Safety

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Chapter 1 - Literature Review

The Food and Drug Administration is charged with protecting consumers from unsafe and impure packaged food and beverage products whether those products are produced near consumer homes or in other countries. One program that the FDA utilizes to ensure the safety of food products is the Total Diet Study (TDS). The Total Diet Study program began in 1961 in Lenexa, Kansas (https://www.fda.gov/food/reference-databases-and-monitoring-programs-food/fda-total-diet-study-tds) and was initially created to measure pesticides, metals, and other contaminants in the foods that United States of America (USA) consumers ingest (Pennington and Gunderson, 1987). The original aim of the TDS was to be a screening tool for evaluating exposure to hazardous elements (Lee et al., 2015). Over time, the program was expanded to include additional nutrients, toxins, and additives (Pennington and Gunderson, 1987). Today, Over time, the program was expanded to include additional nutrients, toxins, and additives

The TDS collects retail food samples from all fifty states to ensure each geographic area is adequately represented. There are six sampling regions as shown in Figure 1: Northeast, Mid-Atlantic, Southeast, Southwest, North Central, and West (FDA, n.d.).

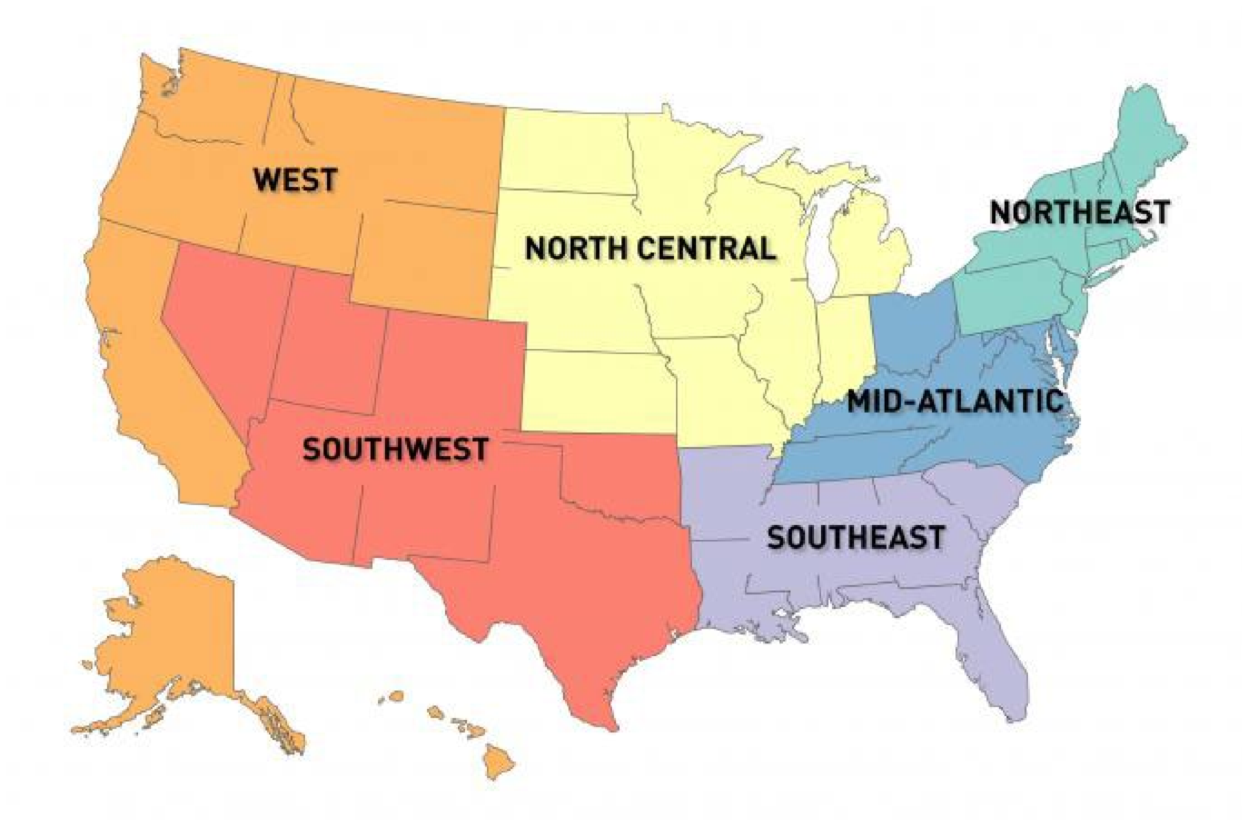

Figure 1.1. *FDA Total Diet Study Collection Regions*

Each region includes several states, and the regions are categorized based on population levels to ensure inequities do not exist. Three larger cities within the region are selected as sampling locations as shown in Figure 2.

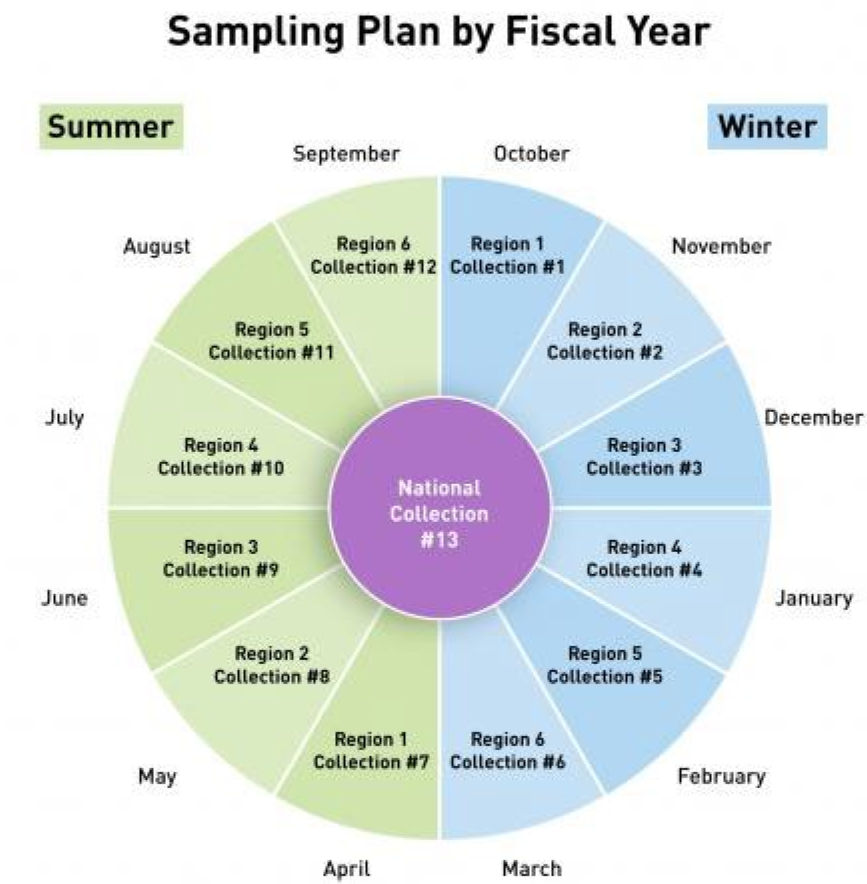

Figure 2.1. ***FDA Total Diet Sampling Plan***

A vast array of food samples is purchased and typically includes the following types of food products: produce, grains, meats, dairy, beverages, snacks, and baby food. The purchased foods from each of the three cities are shipped to the Kansas City Laboratory for testing. Upon arrival, food items are prepared for consumption. The consumable food is then tested in the laboratory to ensure safety (FDA, n.d.).

The TDS data collected can be used to track trends in contaminant levels over short and long periods of time. For example, if the level of lead in cinnamon increases, decision makers can then move forward to determine if there might have been adulteration during processing or less stringent regulations in the countries where cinnamon are grown. Once a cause of the contamination has been established, public health organizations can begin monitoring for exposure to the contaminant and food safety regulations can be considered to restrict the product from entering our food supply and/or require additional product testing. The data collected in the TDS can also be used by dieticians to determine the nutrients that people are consuming through their diet. The TDS analyzes foods after the foods are prepared for consumption rather than as packaged. The preparation method allows for a more accurate picture of what nutrients and contaminants are being consumed vs. analyzing the food as sold and includes a range of foods and beverages to account for vast diets. While the TDS is only utilized in the USA, the methodology utilized by the FDA has been harmonized allowing comparison with the data from other countries (European Food Safety Authority, 2011).

The FDA has consistently utilized advances in technology and methods over the years to provide an increasingly accurate detection of analyte levels and the TDS is routinely updated to include changing dietary trends and preferences (Pennington and Gunderson, 1987). Some of the modern analytical techniques utilized include inductively-coupled plasma mass spectrometry and inductively-coupled plasma atomic emission spectrometry (Hoffman-Pennesi et al, 2019). These techniques are sensitive enough to allow detection in parts per billion whereas between 2000-2015, testing results were found in parts per million. The testing techniques can also be used as a traceback tool, as in many cases the equipment can be used to determine the geographical origin of the food ingredients. Due to the increasingly stringent testing methods, the TDS data is used as a risk assessment screening tool to estimate the probability of an acute or chronic exposure incident occurring and the severity of the potential contamination (Lee et al, 2015).

The FDA has worked in recent years to streamline testing, and the most recent TDS Report includes testing on over 300 foods and beverages for contaminants and 25 elements with a focus on nutrients that are oftentimes low in residents’ diets such as iron and iodine (Winfield et al, 2022). The FDA aims to reduce food testing locations in future years from three locations per region to only one location per region. To reduce testing, one potential change that should be considered is in reference to the shifting of food production and processing chain. In the 1800s, food production in the United States was local or regional; that is, food was produced in an area near where it was consumed. As time marched on, new farming processes were invented and applied on a larger scale (Trimble, 1921). The farming changes, along with improvements to food processing, preservation, and distribution channels, resulted in food ingredients traveling further from the farm before consumption (Elias, 2009). Additionally, in the last fifty years, per capita income has grown while food prices as a percentage of income fell, simulating demand increases in diverse food offerings. Many foods are now produced far from consumers' homes in other states and oftentimes countries. It is estimated that processed food in the United States now travels over 1,300 miles and fresh produce travels over 1,500 miles (Hill, 2008). Because of these shifts in production and manufacturing, it is suggested that TDS should research which foods are being produced nationally vs. regionally. For example, a food product that is manufactured in only one location (i.e. Lucky Charms cereal is produced in Buffalo, NY) would not need to be purchased in many grocery store locations throughout the USA whereas a food product that is manufactured in many regional locations (i.e. bottled water) would need to be purchased at many grocery store locations.

The other project conducted involved adding an escape room in an online Healthcare Economics (HCA-510) class. There are many challenges associated with pursuing a graduate degree, especially an online program. Quantitative classes such as statistics, economics, and finance require students to actively engaged with data to solve problems and interpret data. These tasks can be increasingly challenging for students who did not enjoy math in high school or those who are enrolled in a multidisciplinary program without a background in data related subject matter. Furthermore, communication in online classes is often limited, and the difficulties students face can be compounded when taking quantitative classes (Chimbo, Mutezo, and Maré, 2023). Research has shown that students enrolled in online economics courses tend to be less successful when being compared to face-to-face counterparts (Long, Gebhardt, and McKenna, 2023). This suggests that the online learning experience may not be the best option for all students seeking a graduate degree that includes quantitative classes. One possible strategy to improve outcomes in online quantitative courses is the use of gamification in the classroom (Lampropoulos and Sidiropoulos, 2024).

Gamification is the use of game elements in a context that is not related to games, such as in educational settings. Since the learning curve is steep in data-driven classes, the use of gamification allows for a more interactive and fun learning experience for students, making it an excellent strategy in an online course. One study reported a correlation between gamification and student knowledge retention (Dewi et al, 2024). Another study found that students had an increase in intrinsic and extrinsic motivation following a gamified classroom experience (Lampropoulos and Sidiropoulos, 2024). Gamification has also been shown to promote engagement in an online classroom showing that using learning games can better promote students' engagement in online discussions with peers (Bai et al, 2022).

Chapter 2 - Learning Objectives and Project Description

From December of 2023 until November of 2024, the author completed a field experience working with the FDA's Total Diet Study Program (TDS) housed in Lenexa, Kansas. The author met with preceptor Terry Councell, the Total Diet Study Coordinator, for updates and to discuss data analysis goals and recommendations. Mr. Councell has a B.S. in Geology from George Mason University and a M.S. in Environmental Science from Johns Hopkins University. Mr. Councell has experience in microbiology and chemistry and provided valuable guidance on the agency's goals. Additionally, the author met with a statistician to discuss the data sets obtained and presented at an FDA meeting. The project focused on TDS food sampling frequencies and locations and aimed to determine whether or not food sampling frequencies and locations could be reduced with no changes to data accuracy. The primary research question was whether food samples collected from different locations would produce similar results for nutrients, pesticide residues, and contaminants. To answer this question, three different aims were pursued: (1) conducting Analysis of Variance (ANOVA) analysis on 5997 food and beverage samples from 2000-2023 to determine if there was a statistical difference in analyte and contaminant results between three different sampling locations; (2) performing ANOVA analysis on outlier data between three sampling locations with a dataset comprised of 14233 samples of food and beverages collected during 2022 and 2023; (3) determining the percentage of data sampling results that fell below the Limit of Detection (LOD).

The online learning experience is designed as an escape room. The goal of the escape room was to teach students how to conduct cost minimization analysis given a data set. A scenario was created wherein a rural regional hospital system had a budget shortfall due to rising operational costs. The administration informed departments to find ways to reduce costs without compromising health outcomes. Each team of healthcare economics students conducted a cost minimization study to identify changes to reduce costs yet maintaining outcomes: one department determining whether using telehealth vs. traditional follow-ups for chronic illness appointments; and another department whether medical equipment sterilization should be outsourced. After escaping the room, each team created a sales presentation to the hospital board to justify their savings plan. This project is both relevant and timely, as many rural hospital systems face financial challenges, and students are likely to encounter similar situations after graduation.

The learning objectives of these projects include the ability to improve data analysis proficiency in public health laboratory datasets, engage with decision makers across disciplines to present findings, make recommendations for future data sampling protocols, and create engaging economic analyses into healthcare economics curriculum to train future leaders.

Table 2.1 Summary of Portfolio Products

Portfolio Product		Description
1	ANOVA Analysis Results – 3 Cities	Determine if sampling results from three cities were significantly different using ANOVA data analysis technique.
2	ANOVA Analysis Results – Outliers	Determine if outlier samples were significantly different using ANOVA data analysis technique.
3	Percentage of Samples < LOD Results	Provide data visualizations for various food samples, showcasing the percentage of samples whose concentrations were below the limit of detection.
4	TDS Presentation	Present data analysis findings to the TDS team and provide insights on the differences between regional and national production of retail food offerings.
5	CMA Game-Based Assignment	Create a game-based assignment for a healthcare economics course. The assignment was set in a fictitious hospital, and administrators must decide how to minimize costs due to rising operational costs using Cost Minimization Analysis.

Chapter 3 - Results

The three TDS projects sought to learn whether there is a significant difference between food/beverage analyte sample testing results based on sampling location. The goal was to reduce the number of sampling locations if the results showed no significant differences. Results were mixed in the three data analysis projects and a reduction in testing locations was not recommended based on this analysis. The first data analysis included 109 food and beverage products analyzed using ANOVA technique. Each food or beverage was compared for 27 analytes across the three locations. Examples of some of the foods tested include cereal, syrup, soup, pretzels, peanuts, chips, and gravy. Examples of some of the beverages tested included water, juice, and wine. R version 4.3.2 was used for the analysis and results indicated that only four of 109 analyses were significantly different for the three cities tested. The four samples with a significant difference were all bottled water samples and the differences were found in the levels of antimony, barium, strontium, and magnesium. Since bottled water is typically manufactured regionally, it is possible that regional differences in the public tap water may play a role in the results. No food samples or other beverage samples were significantly different.

The second TDS aim also utilized ANOVA analysis and focused on similar food and beverages such as water, baby food, and peanuts. Unlike the first dataset, this set of samples included at least one of the three cities with known outliers. The outlier dataset included samples from 2022 and 2023 across three cities with a total of 14,233 samples. Typically, only one city per food/beverage sample exhibited analyte results that exceeded testing allowances, and the other two sample locations were within range. Results were compiled in Microsoft Excel 365 and results showed that 62.9 percent of samples were not significantly different, indicating that outliers in data can dramatically impact ANOVA results. Unlike the first project, the number of different food and beverage samples yielded significantly different results. The sample size for each analysis was six, which limits the robustness of the findings. The objective of this project was to determine whether datasets containing outliers would still produce results that were not significantly different. However, the results showed that 37 percent of samples were significantly different, thus not supporting this conclusion.

The third aim examined laboratory data results for 108 food and beverages with varying sample sizes. Most of the foods and beverages in this dataset were foods packaged for babies. Many of the foods and beverages had hundreds of samples, while others had only a few samples. Examples include various brands of jar baby food such as pea, prune, and mango as well as baby formula and juice. The project determined the percentage of samples below the Limit of Detection (LOD). Most of the samples included analyte results at or near 100% of samples being below the LOD. R was utilized to graph the percentages of samples below the LOD. The results indicate that many of the food and beverage samples have laboratory analyte data approaching 0, yet cannot determine whether or not the samples from three different cities are statistically the same.

The results of these studies were presented to the FDA team in Lenexa, Kansas, via Zoom. The results indicated that many of the food and beverages sampled did not have significantly different results based on geographic region. However, during the call, we concluded that more data should be collected. In 2024, the FDA team began collecting data on food and beverages to confirm data analysis results. The author presented information about the differences in food production and processing at the meeting. Many foods and beverages are produced in one location and shipped to many locations. Because of this, testing foods and beverages in several locations may be redundant as the item may come from the same lot number. When the TDS began in 1961, there were very few foods and beverages manufactured in only one location. As time progressed, processors improved their supply-chain and found it financially advantageous to process food in fewer locations. The author suggested that the TDS team should consider working with industry professionals to determine which food and beverage items are produced nationally vs. regionally to understand if multiple testing locations are required.

The final project included the creation of an online escape room to help graduate healthcare administration students to learn more about Cost Minimization Analysis. The analysis allowed students to work together in teams to decide how to respond to a budget shortfall at a rural regional hospital system. At the end of the escape room, students presented their findings to the mock hospital board for potential implementation. The aim of this project is to help students deepen their understanding of data analysis in a low-pressure and engaging environment. While results can be difficult to discern, student feedback has been compiled and comments were largely positive, with several mentioning that they did not know how to use Excel prior to the course and now feel confident in conducting an Excel data analysis in their healthcare organization.

Chapter 4 - Discussion

The datasets were collected over a period of 20 years and, in that time, the testing equipment underwent significant advancements. In 2000, equipment could detect substances at concentrations of parts per million, whereas by 2023, equipment could detect levels as low as parts per billion. Therefore, it is possible that some of the changes observed in the ANOVA analysis were likely due to the increased analytical accuracy rather than actual analyte levels. Another issue raised was in reference to the sampling records. Some of the facilities that sent samples did not list specific cities as the location of the samples, and instead used 1, 2, and 3 as the locations. This sample of data is considered preliminary and should be integrated with additional data.

In the escape room assignment, the cost minimization escape room adds a new skill since students will be responsible for building the Excel spreadsheet with data collected in the scenario. This degree program is multidisciplinary and many of the students who come into the program do not have previous experience using Excel. Perhaps having an Excel bootcamp at the beginning of the program would be another way to integrate data analysis into the program for future students since there will likely be a knowledge gap.

In conclusion, the learning experience proved to be extremely rewarding and valuable. The TDS laboratory data primarily consisted of zeros, which presented unique challenges in data analysis. The nuances associated with analyzing a dataset that was dominated by zeroes had not been previously studied and the sample sizes were much smaller than in previous analyses. Additionally, the healthcare economics development process provided an opportunity for professional growth, particularly in designing an activity where students were responsible for creating their own Excel spreadsheet versus filling in a previously created Excel spreadsheet.

Chapter 5 - Competencies

I have developed skills in the 22 Public Health Foundational Competencies in my coursework. I have also developed further skills in 5 competencies through my APA experience and the ILE products met some of the required competencies of the MPH program, as highlighted in Table 5.1 below.

Table 5.1 Summary of MPH Foundational Competencies

Number and Competency		**Description**
3	Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate.	TDS Data was analyzed to determine whether there is a statistical difference between samples. Utilized ANOVA.
4	Interpret results of data analysis for public health research, policy or practice.	Examine the results of the data analysis and make recommendations for future sampling protocols.
10	Explain basic principles and tools of budget and resource management.	Findings can help reduce costs by decreasing unnecessary retesting. Creating the game-based learning assignment helps explain how resources are managed in a fictitious hospital setting.
14	Advocate for political, social or economic policies and programs that will improve health in diverse populations.	The TDS project work advocates for equitable food safety policies that protect communities disproportionately affected by foodborne contaminants. Explain CMA results to show how project implementation will reduce costs at a medical facility.
19	Communicate audience-appropriate (i.e. non-academic-non-peer audience) public health content, both in writing and through oral presentation.	Present content to TDS team in an interactive format with data visualizations.

The author completed MPH courses covering the competencies found in Table 5.2.

Table 5.2 MPH Foundational Competencies and Course Taught In

22 Public Health Foundational Competencies Course Mapping	**MPH 701**	**MPH 720**	**MPH 754**	**MPH 802**	**MPH 818**
Evidence-based Approaches to Public Health					
1. Apply epidemiological methods to settings and situations in public health practice	x		x		

2. Select quantitative and qualitative data collection methods appropriate for a given public health context	x	x	x		
3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate	x	x	x		
4. Interpret results of data analysis for public health research, policy or practice	x		x		

Public Health and Health Care Systems					
5. Compare the organization, structure and function of health care, public health and regulatory systems across national and international settings		x			
6. Discuss the means by which structural bias, social inequities and racism undermine health and create challenges to achieving health equity at organizational, community and systemic levels					x
Planning and Management to Promote Health					
7. Assess population needs, assets and capacities that affect communities' health		x		x	
8. Apply awareness of cultural values and practices to the design, implementation, or critique of public health policies or programs					x
9. Design a population-based policy, program, project or intervention			x		
10. Explain basic principles and tools of budget and resource management		x	x		
11. Select methods to evaluate public health programs	x	x	x		
Policy in Public Health					
12. Discuss multiple dimensions of the policy-making process, including the roles of ethics and evidence		x	x	x	
13. Propose strategies to identify stakeholders and build coalitions and partnerships for influencing public health outcomes		x		x	x
14. Advocate for political, social or economic policies and programs that will improve health in diverse populations		x			x
15. Evaluate policies for their impact on public health and health equity		x		x	
Leadership					
16. Apply leadership and/or management principles to address a relevant issue		x			x
17. Apply negotiation and mediation skills to address organizational or community challenges		x			
Communication					
18. Select communication strategies for different audiences and sectors	DMP 815				
19. Communicate audience-appropriate (i.e., non-academic, non-peer audience) public health content, both in writing and through oral presentation	DMP 815				
20. Describe the importance of cultural competence in communicating public health content		x			x
Interprofessional Practice					
21. Integrate perspectives from other sectors and/or professions to promote and advance population health		x			x
Systems Thinking					
22. Apply a systems thinking tool to visually represent a public health issue in a format other than a standard narrative			x	x	

Student Attainment of MPH Emphasis Area Competencies

The competencies listed in Table 5.3 were achieved and applied by taking emphasis area classes and engaging in the activities described in this ILE report. I have been teaching healthcare economics courses for over a decade because of my background in economics yet never felt confident in teaching these courses. I started this program in the Summer of 2023 because I primarily teach healthcare economics, and this program has given me confidence when teaching classes in healthcare economics. One interesting agreement I learned about was the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and I was able to use harmonization information when I presented about to the FDA. I also reinforced my previous learnings in public health from my experiences in the Kansas State University Bachelor of Science program in Milling Science and Management and my previous health inspector job through the Kansas Department of Agriculture. I have also found new and engaging ways to present public health information related to economics using examples related to food safety and biosecurity. In my economics and statistics courses, students connect with food-related examples because everyone can relate to buying and consuming food.

DMP 815, Multidisciplinary Thought and Presentation, was the most challenging of my courses because my writing skills are not exceptional. I learned more about how to prepare professional documents and communicate information clearly. The session where a classmate led a meeting was the highlight of the course, teaching me more about meeting protocol. DMP 816, Trade and Agricultural Health and DMP 888, Globalization, Cooperation, and the Food Trade, were my favorite classes in the program. I took them during the same term and that was such a blessing because the information complemented each other. I learned how nations trade food products with other countries and what policies and procedures are in place to prevent trade mishaps. I also learned about zoonotic diseases from years past, such as bovine pleuropneumonia, and how its infectious nature created havoc regarding international relations and economic losses. FDSCI 730, Multidisciplinary Overview of Food Safety and Security, was helpful and provided details about food security and safety with a focus on bioterrorism after 9/11. FDSCI 731, Food Protection and Defense, was a comprehensive course that detailed some of the threats that are present in our food systems and different strategies that can be used when we respond to food safety events.

Table 5.3 Summary of MPH Emphasis Area Competencies

MPH Emphasis Area:		
Number and Competency		**Description**
1	***Food safety and biosecurity***	Evaluate solutions appropriate for different food safety, biosecurity, and defense issues in the food production continuum.
2	***Threats to the food system***	Examine specific threats to the food system and scientifically investigate how each can be prevented, controlled, and/or mitigated in the food production system.
3	***Food safety laws and regulations***	Differentiate key U.S. food safety regulatory bodies and their unique legislative authorities, missions, and jurisdictions.
4	***Food safety policy and the global food system***	Analyze and distinguish how food safety and governmental biosecurity policies, globalization, and international trade cooperation influence public health.
5	***Multidisciplinary leadership***	Contrast the food safety and biosecurity technical needs of different stakeholders and make judgements as to the appropriate methods of collaboration.

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Appendix A

Portfolio Product 1 - Results show no statistical difference in analyte levels between cities 1-3 for 95 food/beverage products and their specific analytes. These results indicate that 96% of samples were not statistically significantly different between cities 1, 2, and 3. Not all products were tested for all 27 analytes with many products being tested for only one or two analytes and more beverage samples vs. food samples being analyzed. The sample sizes were smaller for the food samples vs. the beverage samples and several food/beverage samples were not analyzed due to the small sample size (less than 15 samples per city). While only 4% of samples showed statistically significant differences in cities 1-3, it is important to review those findings.

Barium

Bottled Drinking Water (mineral/spring), not carbonated or flavored was tested for barium levels in cities 1-3. ANOVA analysis was utilized and significance at the alpha of 0.05 was found. The Welch ANOVA p-value is 0.021 and the post-hoc TukeyHSD test confirmed a significant difference in cities 1 and 3 and cities 2 and 3, providing evidence that the city 3 samples had a different mean than city 1 and city 2. The sample size is significant at 148 observations. The boxplot in Figure 1 shows several outliers, specifically in city 3. The data is more dispersed in city 3 compared to cities 1 and 2 as shown in the longer boxplot.

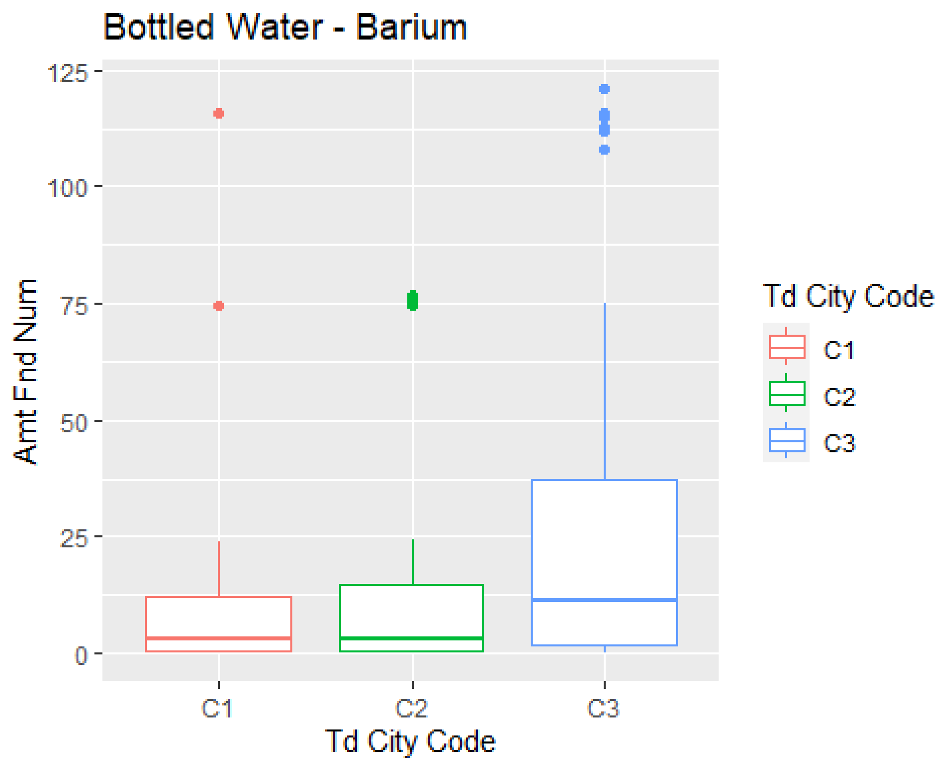


Figure 1

Barium levels in bottled drinking water (mineral/spring), not carbonated or flavored for cities 1-3.

```
##
##  One-way analysis of means (not assuming equal variances)
##
## data:  ‘Amt Fnd Num‘ and ‘Td City Code‘
## F = 4.0421, num df = 2.000, denom df = 88.883, p-value = 0.02089
```

Magnesium

Bottled Drinking Water (mineral/spring), not carbonated or flavored was tested for magnesium levels in cities 1-3. ANOVA analysis was utilized and significance at the alpha of 0.05 was found. The Welch ANOVA p-value is 0.019 and the post-hoc TukeyHSD test confirmed a significant difference in cities 1 and 3 and cities 2 and 3, providing evidence that the city 3 samples had a different mean than city 1 and city 2. The sample size is significant at 134 observations. The boxplot in Figure 2 shows a few outliers in cities 1 and 2, yet less dispersed data overall. City 3 shows data that is more dispersed as shown in the longer boxplot.

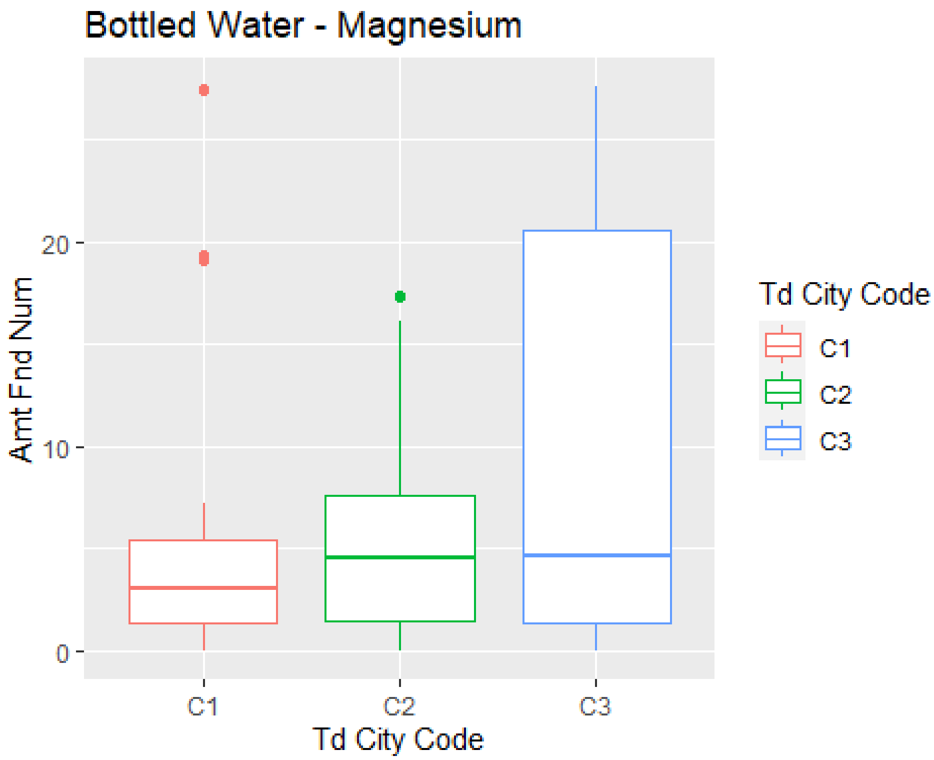


Figure 2

Magnesium levels in bottled drinking water (mineral/spring), not carbonated or flavored for cities 1-3.

```
##
##  One-way analysis of means (not assuming equal variances)
##
## data:  'Amt Fnd Num' and 'Td City Code'
## F = 4.1916, num df = 2.00, denom df = 79.96, p-value = 0.01857
```

Strontium

Bottled Drinking Water (mineral/spring), not carbonated or flavored was tested for strontium levels in cities 1-3. . ANOVA analysis was utilized and significance at the alpha of 0.05 was found. The Welch ANOVA p-value is 0.029 and the post-hoc TukeyHSD test found a significant difference between city 2 and city 3. The sample size is significant at 136 observations. In this sample, cities 1 and 3 both show similar boxplots yet city 2 has a smaller boxplot indicating less dispersed data.

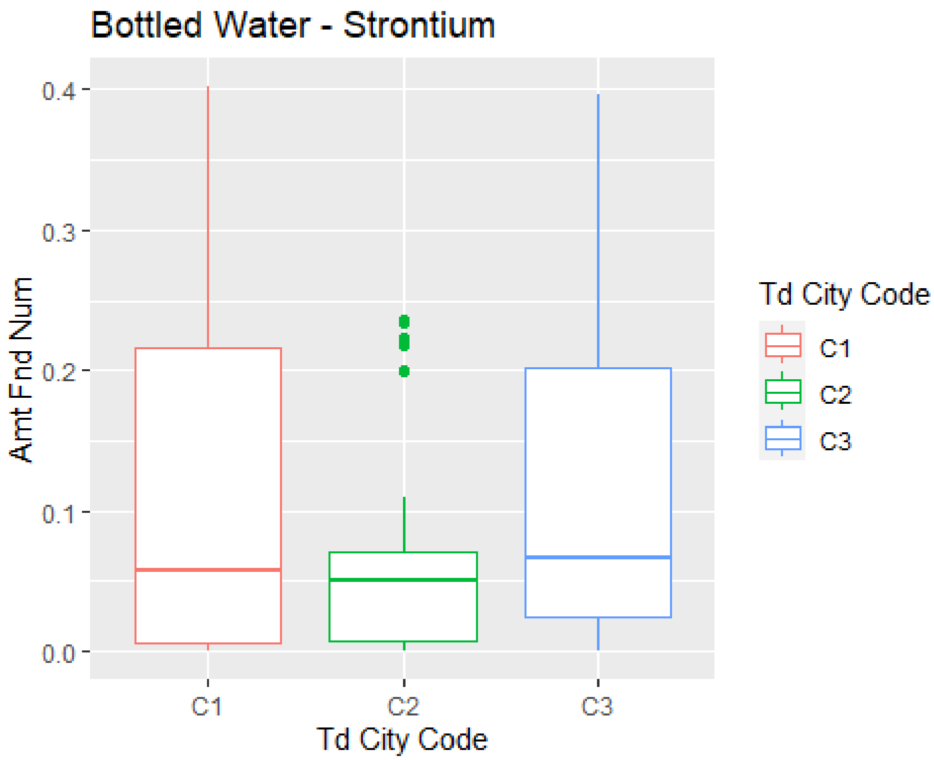


Figure 3

Strontium levels in bottled drinking water (mineral/spring), not carbonated or flavored for cities 1-3.

```
##
##  One-way analysis of means (not assuming equal variances)
##
## data:  ‘Amt Fnd Num‘ and ‘Td City Code‘
## F = 3.7144, num df = 2.000, denom df = 82.708, p-value = 0.02852
```

Antimony

Bottled Drinking Water (mineral/spring), not carbonated or flavored was tested for antimony levels in cities 1-3. ANOVA analysis was utilized and significance at the alpha of 0.05 was found. The Welch ANOVA p-value is 0.002 and the post-hoc TukeyHSD test confirmed a significant difference in cities 1 and 3 and cities 2 and 3, providing evidence that the city 3 samples had a different mean than city 1 and city 2. The sample size is significant at 148 observations. The boxplot in Figure 4 shows a number of outliers in cities 1 and 2, yet less dispersed data overall in comparison to city 3.

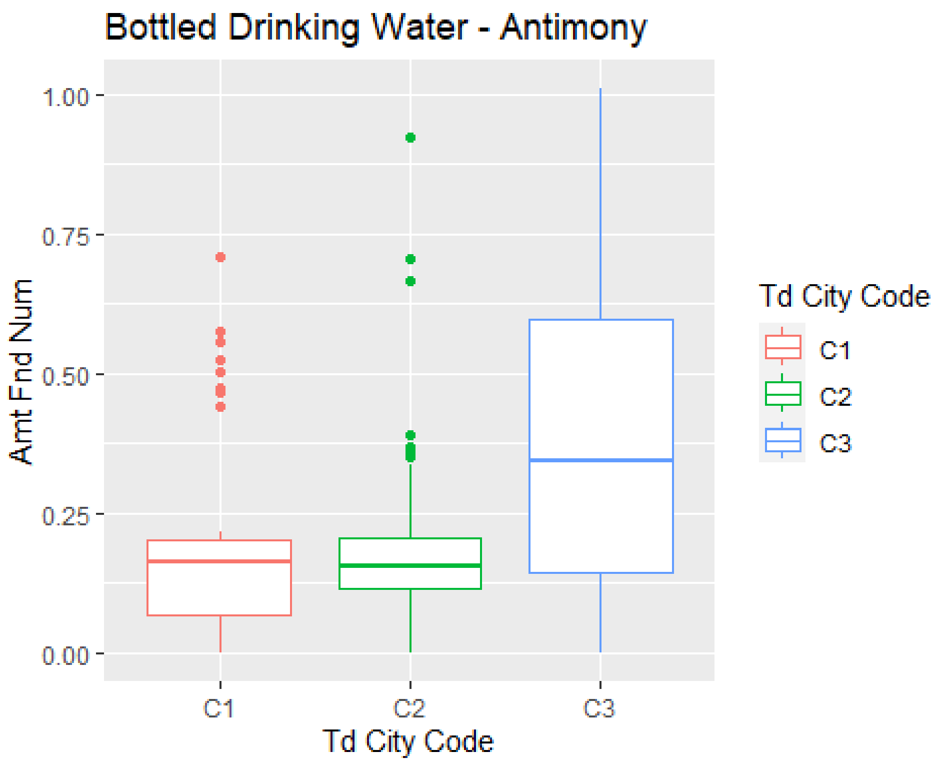


Figure 4

Antimony levels in bottled drinking water (mineral/spring), not carbonated or flavored for cities 1-3.

```
##
##  One-way analysis of means (not assuming equal variances)
##
## data:  'Amt Fnd Num' and 'Td City Code'
## F = 6.7079, num df = 2.000, denom df = 94.102, p-value = 0.001891
```

Appendix B

Portfolio Product 2 – Some of the results from the second TDS project are included in the Excel spreadsheet below. These samples showcase the small sample sizes and the number of samples with analyte levels below the LOD.

Year	Sample Tracking	Basket Number	Description	Analysis Type	Method Code	Analyte	Amount of Analyte	Amount Unit Code

	Number							
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BARIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BARIUM	0.273	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BARIUM	3.14	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BARIUM	3.23	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BARIUM	3.47	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BARIUM	3.48	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BERYLLIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BERYLLIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BERYLLIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BERYLLIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BERYLLIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	BERYLLIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CADMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CADMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CADMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CADMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CADMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CADMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CHROMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CHROMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CHROMIUM	0	U

2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CHROMIUM	0	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CHROMIUM	0.331	U
2020	1142933	6	Water bottled, mineral/spring	Q	ICPMS	CHROMIUM	0.346	U

Lookup Abreviation Description	City Code	Average	P-value (C1 and C4)	P-value (C2 and C4)	P-value (C3 and C4)
ug/kg	C2	2.2655	0.002632	0.040761	0.031131
ug/kg	C2				
ug/kg	C3				
ug/kg	C3				
ug/kg	C1				
ug/kg	C1				
ug/kg	C1		N/A	N/A	N/A
ug/kg	C1				
ug/kg	C2				
ug/kg	C2				
ug/kg	C3				
ug/kg	C3				
ug/kg	C1		N/A	N/A	N/A
ug/kg	C1				
ug/kg	C2				
ug/kg	C2				
ug/kg	C3				
ug/kg	C3				
ug/kg	C2	0.112833	0.02115	N/A	N/A
ug/kg	C2				
ug/kg	C3				
ug/kg	C3				
ug/kg	C1				
ug/kg	C1				

Appendix C

Portfolio Product 3 – Here is an example of the data that was compiled and analyzed in the third TDS aim. There are 192 pea baby food samples, and they have various brand names, such as Gerber Natural for Baby, Beech-Nut, and Gerber Organic. There are 7 labs, 7065 (Alaska), 7092 (Michigan), 7103 (Pennsylvania), 7124, 7125, 7156, 7157 (Arkansas) included. Most of the sample units are ppb, however, there are a few samples without a unit. Several analytes are measured including As, Cd, Cr, Hg, Pb, Inorganic As, Organic as DMA, and Organic as MMA. The percentage of samples below the LOD were calculated and they are shown in the table. There are some instances where the LOD is not listed and therefore LOD zero was assumed.

Analyte	**% of samples below the LOD**
As	83.33%
Cd	75.00%
Cr	83.33%
Hg	95.83%
Pb	100.00%
Organic as DMA	100.00%
Organic ass MMA	100.00%
Inorganic As	100.00%

Appendix D

Portfolio project 4. Below is a copy of the slides presented to FDA.

Agenda

Introduction

Sampling

Data Analysis

Findings

Next Steps

ARE TDS DATA SAMPLING RESULTS STATISTICALLY DIFFERENT WHEN SAMPLING IN DIFFERENT CITIES?

ANOVA

The sample

- 109 food and beverage products
- 27 analytes
- Not all products were tested for all 27 analytes
- Sampling from 2000 -today
- 5997 total samples
- 99 analyses

The sample sizes were smaller for the food samples vs. the beverage samples and several food/beverage samples were not analyzed due to the small sample size (less than 15 samples per city).

Examples of some of the foods tested include cereal, soup, chocolate syrup, pretzels, peanuts, chips, sunflower seeds, and gravy.

Examples of some of the beverages tested include water, juice, and wine.

Sample composition

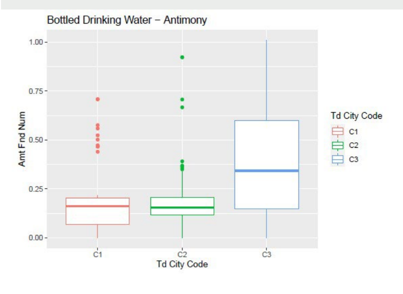
DATA ANALYSIS

ANOVA determines if there is a statistical di–erence in the analyte means between the three cities.

Results

Results show no statistical difference in analyte levels between cities 1 -3 for 95 food/beverage products and their specific analytes.

- The bottled drinking water (mineral/spring) not carbonated or flavored had statistically significant differences in cities 1 -3 when testing for the antimony, barium, magnesium, and strontium analytes.
- The data collected for these analyses was between the years 2016 and 2020.

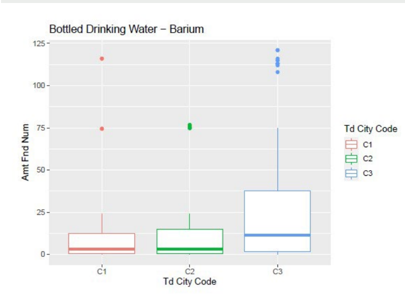


Bottled Drinking Water (mineral/ spring) not carbonated or ëavored.

Antimony

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Amt ~ City, data = bottwatantimony)
##
## $City
##            diff         lwr       upr     p adj
## C2-C1 0.0056600 -0.10033512 0.1116551 0.9912241
## C3-C1 0.1631142  0.05602062 0.2702077 0.0012321
## C3-C2 0.1574542  0.05036062 0.2645477 0.0018957
```

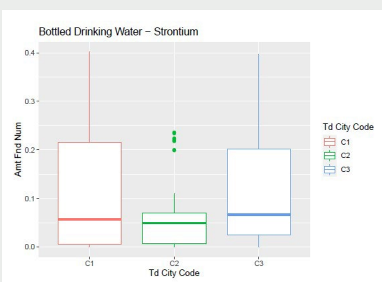
Bottled Drinking Water (mineral/ spring) not carbonated or ëavored.



Barium

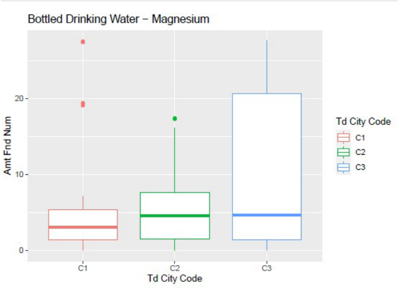
```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Amt ~ City, data = bottwatbarium)
##
## $City
##           diff        lwr      upr     p adj
## C2-C1 -0.51760 -15.761827 14.72663 0.9964423
## C3-C1 19.41239   4.010186 34.81459 0.0092917
## C3-C2 19.92999   4.527786 35.33219 0.0073015
```

Bottled Drinking Water (mineral/ spring) not carbonated or ëavored.



Strontium

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Amt ~ City, data = bottwatstrontium)
##
## $City
##             diff         lwr        upr     p adj
## C2-C1 -0.03215652 -0.08591971 0.02160667 0.3347308
## C3-C1  0.02565543 -0.02871527 0.08002614 0.5044387
## C3-C2  0.05781196  0.00344125 0.11218266 0.0342822
```



Bottled Drinking Water (mineral/spring) not carbonated or ëavored.

Magnesium

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Amt ~ City, data = bottwatmagnesium)
##
## $City
##           diff        lwr      upr     p adj
## C2-C1 0.492913 -3.0808870 4.066713 0.9427989
## C3-C1 5.007277  1.3493765 8.665178 0.0042267
## C3-C2 4.514364  0.8564634 8.172265 0.0112265
```

Results

96% of analyses showed no signiêcant di–erence.

Most retail food and beverages travel 1,500 miles between production and consumption.

Beverages may be bottled regionally.

Spring water is likely not as êltered as other bottled water?

Next Steps

Is there a signiêcant di–erence in the number of samples that are out of range between cities 1 - 3? Use Chi - Square.

Is there a trend in analyte levels? Use Multiple Regression.

Which food/beverages are produced regionally?

What ingredients have the most contaminants/pesticide residues?

THANK YOU

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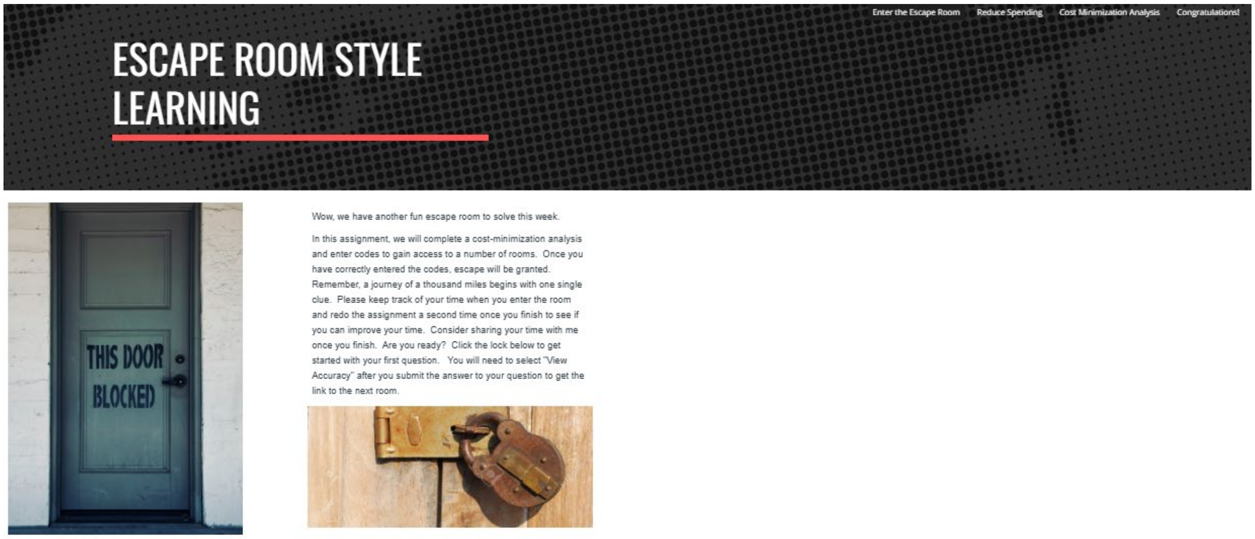
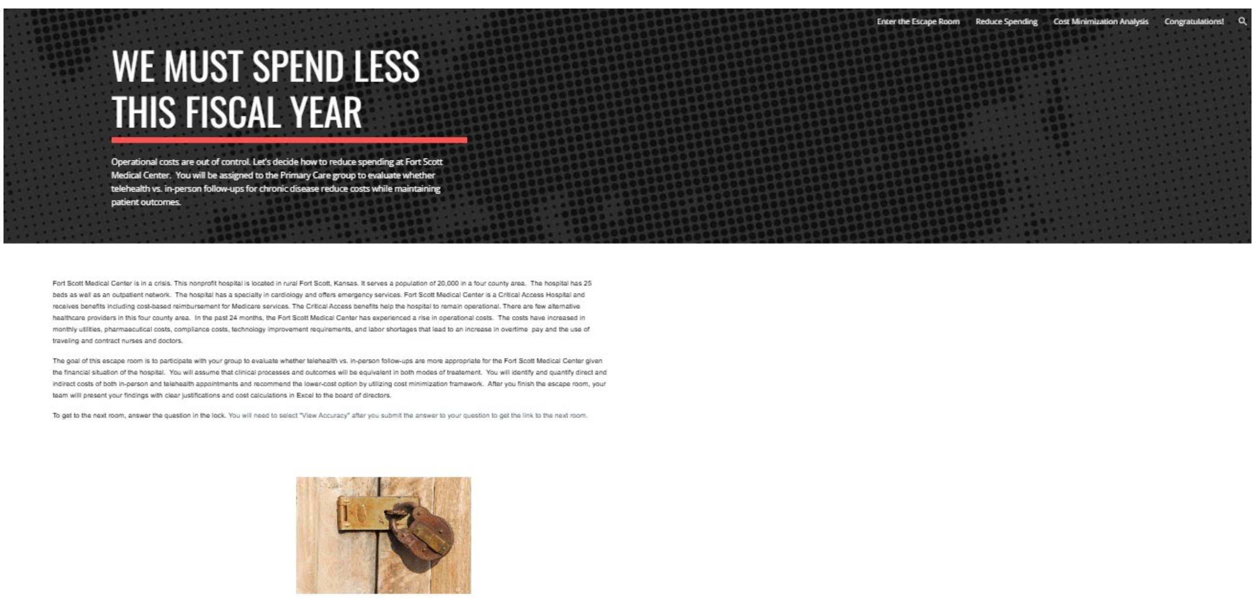
Appendix E

Portfolio project 5. Below is a series of screenshots illustrating the cost minimization analysis in the escape room game.





Enter the Escape Room   Reduce Spending   Cost Minimization Analysis   Congratulations!

COST-MINIMIZATION ANALYSIS

Cost minimization analysis can be used to determine which project should be selected by comparing direct and indirect costs - choosing the least expensive option that will maintain the same level of health outcome. In healthcare situations, cost minimization can be used for a variety of applications. Some example applications include comparing generic and name brand drugs and determining whether to offer services in-house or to have the services outsourced. This type of analysis is only appropriate when you know that the health outcomes are the same.

You work at Fort Scott Medical Center, in the Chronic Care Department. You and your team will assess whether to shift follow-up appointments to the Chronic Care team from in-person appointments ot telehealth appointments. Research has shown that in many facilities, chronic care management by telehealth yields equivalent health outcomes vs. in-person appointments. Your objective is to identify the lower-cost option at Fort Scott Medical Center by using Cost-Minimization Analysis. Chronic care follow-ups are a high volume visit at the hospital. You will create your own Excel spreadsheet and Row 1 of the spreadsheet will include the titles of each cost. Row 1 will list the costs for Telehealth and Row 2 will list the costs for In-person visits.

Here are the costs to consider.

Telehealth
Telehealth does not have a facility cost, but does require Internet and access to the hospital's Zoom for Healthcare account which costs $15 per session. Scheduling/administrative costs are estimated to be $10 a visit. There would not be a need for travel reimbursement and the Physician cost per visit is limited at $40.

In-person appointments
The in-person appointments incur at $90 Physician cost per visit and the travel reimbursement to Fort Scott is $35 a visit. The facility costs include $80 per visit and cover the building and equipment costs. There is also a cost of $25 for scheduling and aministrative costs.

Enter the Escape Room   Reduce Spending   Cost Minimization Analysis   Congratulations!

CONGRATULATIONS

"It is the act of solving puzzles that makes games fun." -Raph Koster, Game Designer.

You selected the correct chronic care follow-up appointment type! Congratulations on escaping the rooms. Continue on to learn more about how to complete the Board of Directors Recommendation Presentation with your team.

Your team of five will now work together to recommend Follow-Up Appointments to the Board of Directors in an effort to cut operational costs. The slide presentation will be 8 slides in length with multimedia. You can feel free to add information that is not mentioned in the scenario, but would be common in smaller rural hospitals.

Slide one will be a title page slide with the title: Follow-Up Appointments. Below the title, include each team member's name in the Chronic Care Department. Include the date.
Slide two will include a background detailing the financial situation at the hospital. Explain the number of appointments that your facility has each month and detail the goal of your escape room.
Slide three will provide background on what cost-minimization is and how it can be used in a hospital setting. Please use extenal resources in this slide to reinforce what you learned in this escape room.
Slide four will include the data and calculations for Telehealth appointments. You will explain the data in the multimedia presentation.
Slide five will include the data and calculations for In-person appointments. You will explain the data in the multimedia presentation.
Slide six will compare the costs between the two types of appointments.
Slide seven will include your team's recommendation.
Slide eight will include information on the next steps to carry out this program. The change might suggest a pilot program to start with, or perhaps mention the need to monitor satisfaction using surveys.