

ACCIDENT REPORTING FOR BULK MILK HAULING
WITHIN THE STATE OF MISSOURI

by

William H. Benedict

An Abstract

of a thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
in the School of Technology
University of Central Missouri

December, 2014

ABSTRACT

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A literature review has shown that there is a need for dedicated bulk milk hauling research that identifies ways to preserve quality by reducing risks of driving accidents. Reduction of driving accidents will increase public safety, save costs to the milk industry as well as government agencies and emergency responders, and reduce risks of low quality milk reaching processors. This study looks at seven years of historical data on bulk milk hauler accidents within the State of Missouri as a population. The purpose of this study is to determine factors that may be related to bulk milk hauling accidents in the state of Missouri, and provide a perspective in understanding the historical data available. Analysis of the historical data presented significant statistical findings that there is a positive relationship between the dispersion of dairy producers within the state and the occurrence of bulk milk hauling accidents. There also exists a lower level of significance in the relationship between the dispersion of dairy processors within the state and the occurrence of bulk milk hauling accidents. Data analysis also presents the finding that the load size of the tanker trucks which experience accidents is not an independent factor when compared to the occurrence of that accident. It is concluded that these findings represent a foundation for continued research to identify causal factors related to the occurrence of bulk milk truck accidents within the State of Missouri.

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APPROVED:

Thesis Chair: Dr. Ronald C. Woolsey

Thesis Committee Member: Dr. Suhansa Rodchua

Thesis Committee Member: Dr. Ronnie Rollins

ACCEPTED:

Chair, Department of Technology: Dr. Douglas Koch

UNIVERSITY OF CENTRAL MISSOURI
WARRENSBURG, MISSOURI

ACKNOWLEDGMENTS

I would like to thank the University of Central Missouri, School of Technology, for providing an avenue for pursuit of a career in Quality. With the combination of classes, student memberships, and professional networking, I feel that my education has been well rounded and I am grateful for the opportunities available to go above and beyond. I would like to directly thank Dr. Suhansa Rodchua for her dedication to the field of Quality, and being the pivotal driver in the department. It is her belief in the need for Quality that has helped me realize the importance of the discipline. I also call attention to Dr. Ronald Woolsey, who has been the stern eye who has pushed me and honestly guided me toward success of this Master's Thesis. Dr. Ronnie Rollins needs special mention as a great resource who supported my endeavors into robotics and computer hardware integration.

I am most thankful for the loving support of my wife, Gwendolyn, for supporting my return to higher education. Without her trust and sponsorship, this Master's Degree would not have been possible so early in my career. Often times the voice of reason, she has been helpful in pushing myself to act as a leader on campus, and also to support the local community.

There is a special place in my heart for the Warrensburg High School Robotics Team, The Burger Bots, and specifically Mr. Brian Holmgren. Brian is lead mentor for the robotics team, and I have found great humbling and realization of self-worth while working with him to support high school students explore the joys and hardships of robotics.

Finally, I thank my family. My father Thomas, mother Julia, and brother James, who shaped me into the person I am today. A creative and humorous person with the drive and devotion to see things through, and not back down from a challenge.

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CHAPTER 1 INTRODUCTION

Milk is vulnerable to many forces that can reduce quality during the transportation stage of operations, and therefore requires an extra skill set for bulk milk haulers. This extra skill set comes in the form of quality sampling, testing, and sanitary operations. These skills are stacked on top of the requirements for safe driving of large trucks on public roadways. This raises the question: Does a focus on such an extra skill set reduce the ability for bulk milk haulers to maintain safe driving records? And, what are the factors that may correlate to accident rates of bulk milk haulers. If a bulk milk hauler completes all milk related operations in a perfect fashion, and maintains the quality and value of the raw milk, there is always the risk that the entire amount of work and product value will be lost by a driving accident.

The milk industry of Missouri represents a vital part of society as milk is consumed daily in many households, and is used for many other food products. A study at the University of Missouri estimates that the total economic output of Missouri's dairy industry was roughly \$7.7 billion, and added \$2.0 billion to Missouri's gross domestic product (Horner & Milhollin, 2013). The products manufactured from milk in Missouri includes fluid milk, specialty milk drinks, yogurts, ice creams, frozen custards, infant formula, health supplements, sports drinks, energy drinks, cheeses, flavoring agents, dry dairy ingredients, and many other more specific products. Many industries have seen growth due to their involvement with the dairy industry, adding to the infrastructure of Missouri.

Employment is an important factor in the dairy industry, with 5,515 workers earning an average salary of \$46,850 as reported in 2011, and the total employment supported in some way

by the dairy industry within Missouri is estimated at over 23,000 across the state (Horner & Milhollin, 2013). A few major trends have been seen in the recent years of the dairy industry of the United States, as identified by Horner and Milhollin in 2011. These include: (1) the migration of milk production to larger dairies in western states, (2) the consolidation of grocery stores, (3) increased regulation of milk in schools and a reduced per capita demand for fluid milk, (4) rising demand for cheese and cultured dairy products, (5) increased export demand for U.S. dairy products, and (6) increasing local foods while connecting with producers. These trends have influenced the Missouri dairy industry to consolidate commercial plants, increase production of specialized products, and also encourage farmer processors and cooperatives to build local brands.

It is clear that Missourians have invested great time and energy into establishing the dairy industry within the state. In order to maintain this industry, the state needs to support the infrastructure and foundation. Bulk milk haulers are part of this structure and foundation as every dairy product comes from raw milk which is hauled in a tanker truck at some point in the supply chain. Of the 5,515 workers employed directly by the dairy industry in 2013, 296 held a bulk milk hauler licenses making up 5.3% of the workforce. It could be seen that by increasing the operational ability and reducing risks within bulk milk hauling, a small focus can have wide spread benefits within the industry.

STATEMENT OF THE PROBLEM

A literature review has shown that there is a need for dedicated bulk milk hauling research that identifies ways to preserve quality by reducing risks of driving accidents. Reduction of driving accidents will increase public safety, save costs to the milk industry as well as government agencies and emergency responders, and reduce risks of low quality milk reaching processors. Low quality or contaminated milk which reaches processors may be mixed with other ingredients and end up causing resultant contamination of products which may require disposal of entire batches, recall of product from stores, or worst case scenario, health issues within the consuming public.

Furthermore, the state of Missouri is in a unique situation in that it has a strong and growing dairy industry, but is not regarded as being in the top 20 milk producing states. Missouri is currently ranked 25th as reported by the United States Department of Agriculture for total milk production with 1.3 billion pounds of milk in 2013. These factors indicate that Missouri may be entering the top 20 states for milk production in the near future, and to do so needs to better understand their situation regarding how milk is being transported within the state.

STATEMENT OF PURPOSE

The purpose of this study is to determine factors that may relate to bulk milk hauling accidents in the state of Missouri, and provide a perspective in understanding the historical data available. The primary focus will fall on historical data available from the Missouri Department of Agriculture's State Milk Board, operating out of Jefferson City, Missouri. Descriptive

analysis can be compared and contrasted to other state's findings and also to an overall national level as data is available to do so, in hopes of better understanding the situations that are unique to Missouri, or are shared across state borders. A goal of this research is to identify areas for growth within the data tracking process of reporting bulk milk hauler accidents. As such, this research is a starting point for dedicated analysis of bulk milk transport by truck, specifically within the state of Missouri.

SIGNIFICANCE OF THE STUDY

This study presents a current state perspective through the viewpoint of data from the Missouri State Milk Board. Based on historical data held by state government, this perspective provides a realistic view of what is deemed important information to track for the purposes of the State Milk Board's operations. It is important to note that this is the entirety of information kept since the start of data tracking in 2007. It is the goal of the State Milk Board to provide safe dairy products to consumers while ensuring fair market prices within the industry.

By limiting the data to a single state, the primary stakeholders on the subject are also limited to the producers, transporters, and processors operating within the state. Producers could use this information selecting destinations for their milk and selecting business partners and customers. Transporters could use this information to identify areas of risk in order to undertake extra precaution during certain situations. Processors could use this information to identify risk in their supply chain, or dedicate resources to help enable better operations within the supply chain. Other stakeholders could include producers, transporters, and processors operating outside the state but looking to expand their operations to include regions of Missouri. A further

removed group of stakeholders would be other states with similar milk production statistics which are looking for information to benchmark themselves in studies of their own.

LIMITATIONS

The completeness of data is assumed to be honest and accurate as provided by the Missouri State Milk Board through request by enacting the Missouri Sunshine Law, which makes documents of public record available to those requesting.

RESEARCH QUESTIONS

1. Is there a relationship between the number of dairy processors in a region within the state and the number of accidents seen within that region?
2. Is there a relationship between the number of dairy producers in a region within the state and the number of accidents seen within that region?
3. Does a relationship exist between how many new licenses are given and how many accidents occur each year?
4. Is the accident frequency related to load sizes of empty, half-full, or full tanks?

RESEARCH HYPOTHESES

H_{01} : There is no significant relationship between the number of dairy processors within a region of the state and how many accidents occur within that region.

H_{a1} : There is a significant relationship between the number of dairy processors within a region of the state and how many accidents occur within that region.

Ho₂ : There is no significant relationship between the number of dairy producers within a region of the state and how many accidents occur within that region.

Ha₂ : There is a significant relationship between the number of dairy producers within a region of the state and how many accidents occur within that region.

Ho₃ : There is no significant relationship between how many new bulk milk hauler licenses are given and how many accidents occur each year.

Ha₃ : There is a relationship between how many new bulk milk hauler licenses are given and how many accidents occur each year.

Ho₄ : The variable of accident frequency of bulk milk trucks and the variable of load sizes being empty, half-full, or full tanks are not independent.

Ha₄ : The variable of accident frequency of bulk milk trucks and the variable of load sizes being empty, half-full, or full tanks are independent.

DEFINITION OF TERMS

1. *Bulk Milk Hauler*: “A licensed person who grades, samples and measures milk in a farm bulk tank; pumps milk from the tank and delivers the milk to a dairy plant, receiving station or transfer station” (Missouri State Milk Board, n.d., pg 4).
2. *Contamination*: “To soil, stain, corrupt, or infect by contact or association. To make unfit for use by the introduction of unwholesome or undesirable elements” (Merriam-Webster, 2014).

3. *Dairy Producer:* “The person or persons who exercise the control over the production of milk delivered to a processing plant or receiving station, and those who receive payment for this product.” (Missouri State Milk Board, n.d., p. 4).
4. *Dairy Processor:* Generally speaking, a dairy processor is a business entity which receives raw milk products from a Dairy Producer and uses the liquid in producing a product. Products range from assorted beverages to butter, cheese, and more.
5. *Milk:* “The normal lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows or goats” (Missouri State Milk Board, n.d., pg 4).
6. *Milk Grade A:* Generally speaking, grade A milk is milk which is of a quality fit for human consumption (US Department of Health and Human Services, 2011).
7. *Milk Grade B:* Milk which is of a quality fit only for further manufacturing into other products, and not fit for direct human consumption (US Department of Health and Human Services, 2011).
8. *Missouri State Milk Board:* “State Milk Board (SMB) was created in 1972 to encourage orderly and sanitary production, transportation, processing and grading of fluid milk and processed milk products for consumption intrastate as well as interstate” (Missouri Department of Agriculture, 2014, p 1).
9. *Quality:* “The sum of all features and characteristics of a product that affect its ability to satisfy customer needs” (Smith, 2013).

10. *Quality Decay*: Over time, a product loses the ability to meet customer needs, and therefore has an expiration date associated to that product (Rong & Grunow, 2010).
11. *Shelf Life*: “Products are often perishable and cannot be stored indefinitely” (Rong & Grunow, 2010, pg 960).
12. *Supply Chain*: “The system of organizations, people, activities, information and resources involved in producing and/or moving a food product to the customer” (GMA, 2008, pg 6).
13. *Tanker Truck*: “A bulk milk pickup tanker (Tanker Truck) is a vehicle, including the truck, tank and those appurtenances necessary for its use, used by a bulk milk hauler/sampler to transport bulk raw milk for pasteurization from a dairy farm to a milk plant, receiving station, or transfer station” (US Department of Health and Human Services, 2011, pg 2).

CHAPTER 2 REVIEW OF LITERATURE

In continuous improvement initiatives found in quality management, it is often beneficial to segment complex and complete systems into smaller areas of focus in order to better limit and control the variables therein. A Food Supply Chain (FSC) is one such complex system composed of organizations which produce and distribute vegetable or animal-based products to consumers (Van der Vorst, J. G. A. J, Beulens, A. J. M., and Van Beek, P., 2005). A FSC contains all aspects of the industry from original production of plants or animals, harvesting, processing and packaging, storage and distribution, to final display and sale to customers.

From a business standpoint, food products have a special set of limiting factors including perishability or shelf life, natural quality decay, risk of contamination, and others which all can affect the final value and selling price of the product (Rong & Grunow, 2010). To best be able to supply a quality product (high value), an organization must understand their products' quality attributes and maintain operations which support their customers' demands (Westcott, 2006). Furthermore, for a company to maintain competitive advantage, a specific level of food product quality must be delivered to the right customer to maximize revenue, taking into account remaining shelf life and routing through the supply chain (Ahumada & Villalobos, 2011). And thus, it can be assumed that with increased quality comes increased value of a product, therefore accidents and risk must be avoided at all costs to ensure that the high value product reaches the buying customer. From the previous statements it can be understood that with the complexity of a FSC comes the increased ability for operations to affect the quality of a food product, as every segment of the supply chain contains its own set of risks and concerns which can impact the

delicate nature of food products. This paper will segment the general FSC and focus on the transportation of raw milk. And more specifically, the transportation of bulk milk traveling from producer to processor.

A further segmenting of the transportation aspect of FSCs identifies modes of transportation to be truck, rail, boat, and airplane. A study into fresh produce distribution showed results that transportation by truck provides the best ability to maximize revenues as well as react to different quality considerations after application of a quantitative planning model (Ahumada & Villalobos, 2009). With considerations for product quality and operational costs being a focus in this research, it has been decided that transportation by truck is the appropriate segment to study. Historically, the milk industry has realized the need for a flexible and responsive system of distribution due to the remote location of producing farms, and the perishability of product, and the need to support a strong customer base. The term Milk Run is commonly used in distribution of many goods when a vehicle will deliver a product, then return with another item, usually the packaging from the original delivery for recycling or reuse. Originally in urban society, milk was delivered in glass bottles directly to a customer's door step, and the customer would leave the empty bottles on the doorstep for pickup. This sort of two way transportation includes some valuable operation during both directions of travel, and is a good use of resources. On the producer to processor side of milk transportation, empty trucks go to a producer, and full trucks deliver to the processor. Milk Runs do not appear in bulk milk hauling so risks and failures that occur are magnified on an operational cost perspective.

Milk is vulnerable to many forces that can reduce quality during this stage of operations, and therefore requires an extra skill set to be had by bulk milk haulers. This extra skill set comes in the form of quality sampling, testing, and sanitary operations. These skills are stacked on top of the requirements for safe driving of large trucks on public roadways. This raises the question: Does a focus on such an extra skill set reduce the ability for bulk milk haulers to maintain safe driving records? And, what are the factors that may correlate to accident rates of bulk milk haulers. If a bulk milk hauler completes all milk related operations in a perfect fashion, and maintains the quality and value of the raw milk, there is always the risk that the entire amount of work and product value will be lost by a driving accident.

NATIONAL ACCIDENT REPORTING FOR LARGE TRUCKS

In the United States, there are seemingly endless national highway systems, state highways, and roads. According to the Federal Highway Administration, it is important to maintain the National Highways System for purposes of economy, security, ability for the pursuit of happiness, and in 1995, over 160,000 miles of freeways were dedicated to the National Highway System (1996). This National Highway System connects 198 ports, 207 airports, 67 Amtrak stations, 190 rail to truck terminals, 82 intercity bus terminals, 307 public transit stations, 37 ferry terminals, 58 pipeline terminals, and 20 multipurpose passenger terminals; Ninety percent of the US population lives within five miles of the National Highway System (Slater, 1996). This dedication to infrastructure enables the American economy and provides opportunity to the nation.

In order to manage the economic use of the National Highways System and all the roads of the United States, the Federal Government has developed two entities which track data and work to maintain safe operations of these road systems: The Federal Motor Carrier Safety Administration (FMCSA) and the Office of Information Management. The FMCSA has a goal “to reduce the number and severity of large truck- and bus-involved crashes,” which it seeks to accomplish by increased vehicle and operator inspections and compliance reviews, stronger enforcement of measures against violators, faster rulemaking proceedings, scientific research, and effective commercial driver’s license testing, recordkeeping, and sanctions (FMCSA, 2006, p. 1). The Office of Information Management is required to collect and analyze motor carrier data and make this data available to the motor carrier industry. The two departments work together closely to fulfill goals of the FMCSA and increase public safety while maintaining economic stability within motor carrier industries.

A three year study into the causation of large truck crashes was conducted by the FMCSA and covered the span of April 2001 to December 2003, providing data to detail the physical events of each crash, and including information about all vehicles and drivers, weather and road conditions, and trucking companies involved. The data was collected within 17 states and the sample included 967 crashes all resulting in serious injury or fatality. Upwards of 1000 data points were gathered from each crash site. Statistical methods were used to determine contributing factors and causes of large truck crashes. The study focused on 10 critical issues for investigation, ordered by their perceived importance, and outlined information that can be used to address each issue. The 10 critical issues include: (1) Problem Identification, (2) Driver

Fatigue and Hours of Service, (3) Vehicle Maintenance and inspections, (4) Relative Roles of Cars and Large Trucks, (5) Driver Working Environment, (6) Role of Environmental Factors, (7) Truck Driver Performance, (8) Vehicle Design and Load, (9) Truck Driver Licensing and Monitoring, and (10) Truck Driver Training and Experience.

Descriptive analysis of the study showed that 62.2% of all accidents included a tractor pulling a semi-trailer (FMCSA, 2005). Most bulk milk haulers utilize this transportation configuration of tractor and trailer (Ebra, Wasserman, and Pratt, 1993), putting them into the highest percentage category for severe crashes. The finding of the study identify twenty most occurring factors, and six factors of interest, which are presented in Table 1. Several categories are seen in the table, showing driver related factors, vehicle factors, and environmental factors. The percentages represent the unweighted totals of the original 967 crashes observed by the Federal Motor Carrier Safety Administration of the United States.

Table 1

Top 20 Crash Related Factors with Associated Sample Percentages

<u>Group</u>	<u>Factor</u>	<u>Percent</u>
Driver	Prescription Drug Use	26.3%
Driver	Traveling Too Fast for Conditions	22.9%
Driver	Unfamiliar with Roadway (less than 6 times in 6 months)	21.6%
Driver	Over-the-Counter Drug Use	17.3%
Driver	Inadequate Surveillance	13.2%
Driver	Fatigue	13.0%
Driver	Under Work-Related Pressure	9.2%
Driver	Illegal Maneuver	9.1%
Driver	Inattention	8.5%
Driver	External Distraction Factors	8.0%
Driver	Inadequate Evasive Action	6.6%
Driver	Aggressive Driving Behavior	6.6%
Driver	Unfamiliar with Vehicle (less than 6 times in 6 months)	6.5%
Driver	Following Too Closely	4.9%
Driver	False Assumption of Other Road Users Actions	4.7%
Vehicle	Brake Failure, out of adjustment	29.4%
Environment	Traffic Flow Interruption	28.0%
Environment	Roadway Related Factors	20.5%
Environment	Driver Required to Stop Before Crash	19.8%
Environment	Weather Related Factors	14.1%
Other	Cargo Shift	4.0%
Other	Driver Pressured to Operate While Fatigued	3.2%
Other	Cargo Securement	3.0%
Other	Illness	2.8%
Other	Illegal Drug Use	2.3%
Other	Alcohol Use	0.8%

Federal Motor Carrier Safety Administration, 2005

Further considerations and analysis in the FMCSA study concluded that the large truck was assigned the critical reason for the crash in 55% of the cases, and that 87% of those critical reasons were attributed to the driver (FMCSA, 2005). This leaves only 13% of critical reasons for crashes attributed to the truck, weather conditions, or roadway problems. This percentage falls in the same realm as a highly regarded crash causation study conducted in 1979, where 93% of crashes included driver error as found by Treat, Tumbas, McDonald, Shinar, Hume, Mayer, Stansifer and Catellan. The methodology of the FMCSA's three year study explains that there is no single causing factor or critical reason why a crash occurs. It does explain, however, that high frequency of associated factors can be justification that the presence of that factor will increase the risk of a crash (Blower & Ralph, 2005). The data points collected were primarily based on physicality of each crash, and what could have caused that physical situation to occur prior to the crash. For this reason, Blower and Ralph indicated that it is entirely possible and probable that certain factors will occur together in crash data or are more likely in some instances than others (2005). It would then be beneficial for all available factors to be considered for full understanding of a crash situation, but certain factors when removed are more likely to reduce the risk of an accident.

BULK MILK CHARACTERISTICS

Missouri is ranked in the top 25 states for milk producers with 889 grade A dairy farms and 339 grade B dairy farms, as reported by the Missouri Department of Agriculture (2014). The grading of raw fluid milk is required by section 196.935 of Chapter 196 of Missouri statutes. The classification of grade A milk indicates that this fluid grade milk was produced under sufficiently

sanitary condition, and is of enough quality that it may be consumed as a beverage. Grade B, or manufacturing milk, is not of beverage quality and can only be used in milk products such as cheese, butter, and non-fat dry milk. In truth, many food product companies require Grade A milk from their producers in order to maintain and market quality to their customers. Operations in milk transportation differ very little based on the grade of the milk, and sanitary regulations are enforced for both.

Characteristics of milk enable specific handling and processing precautions. Milk is a solution that is 87% water, so can be easily contaminated, and its high nutritive value make an ideal environment for multiplying bacteria. To maintain the quality of bulk milk, many samples and tests are performed throughout the supply chain from producer to consumer, including during transportation operations. Reasons for maintaining quality can be seen through the eyes of the consumer who knows that they are buying and consuming a safe product, the processor who purchases the raw milk requires certain qualities depending on the dairy product being produced, or the producing dairy farmer who wants to receive a fair price for their quality of milk. Finally, local and international government agencies need to know that the health and nutritional needs of the public are being considered, and that good business practices are being followed. Fulfilling the wants and needs of all these customers is only possible by quality testing and sampling, coupled with quality assurance systems to maintain acceptable standards.

During the operations in Bulk Milk Hauling, there are specific quality concerns that a driver must be ready to identify and act on. Temperature of bulk milk must legally be maintained between 34 – 40 degrees Fahrenheit, yet optimally temperatures should not exceed 36 degrees (USDA, 2011). Some companies hold more strict quality regulations and have the

narrow temperature range of 34 – 36 degrees Fahrenheit. Bacteria growth can rapidly occur at temperatures above 45 degrees so it is important that all refrigeration equipment is working properly and is calibrated. Other concerns with milk quality include fat clumping, foaming, freezing, feed odors, blood presence, and contamination. If a tank of poor quality milk is not identified, then it will be pumped into the tanker truck and mix with the milk from previous or later pick-ups, spoiling the entire truck load.

DUTIES OF BULK MILK HAULING

Bulk Milk Hauling requires a dedicated arsenal of equipment and skill, and in suit provides a unique situation when trying to analyze accident patterns during transportation as added stress from industry pressures could increase risk to driver performance. “Sampling and measuring milk are important duties to insure a fair and accurate transaction between the producer and buyer” (Missouri State Milk Board, n.d., p. 3). Many stakeholders rely on the Bulk Milk Hauler for proper execution of duties and maintaining the reliability of equipment. “Only a licensed bulk milk hauler can grade, sample, measure and pump milk from a farm bulk tank and deliver the milk to a dairy plant, receiving station or transfer station” (Missouri State Milk Board, n.d., p. 3). Furthermore, the Bulk Milk Hauler is often the most visible contact between producers and processors, and personal relationships can develop, so it is imperative that the Bulk Milk Hauler is able to maintain a professional, ethical, and sanitary working environment. The Missouri Bulk Milk Hauler Sample Manual states that “a clean outward appearance of the bulk truck establishes confidence in the hauler’s ability to handle a food product” (Missouri State Milk Board, n.d., p. 5).

The basic duties of a Bulk Milk Hauler include measuring, sampling, pumping, and transporting milk. These duties require specific supplies and equipment to maintain satisfactory sanitary operations and the quality of milk. The following list of duties is a summary of those duties found in the Missouri Bulk Milk Hauler Sampler Manual which have been categorized by the time at which the duties occur, and also give a preview of what equipment is used during that operation:

Pre-Route:

1. Wash and sanitize truck and transfer equipment if check shows need.
2. Check for wash tag (tank) which details time/date, type of sanitizer, etc.
3. Inventory sampling equipment in truck including sample containers, sample transfer instrument, sanitizing solution, insulated sample carrying case, ice or other refrigerant to maintain sample temperature.
4. Maintain calibrated thermometer with adjustable calibration.
5. Inventory other equipment needed including sani-guide discs, waterproof marker for sample identification, timing device, milk weight tickets and pencil, single-service paper towels, and a flashlight.

Sampling and Pick-Up:

1. Acquire odor and appearance of milk, identifying for off-odors and visual indication of poor milk quality.
2. Measure the milk volume and temperature with facility provided equipment.
3. Sample milk after correct agitation and settling time, recording producer number, hauler initials, route number, date, time, and temperature. At first pick-up, collect a

second sample to be identified as the temperature control sample for the refrigerated sample case.

4. Immediately place samples in refrigerated sample case after sampling.
5. Wash and sanitize sampling equipment.
6. Place sani-guide disc (filter) between producer tank valve and transfer hose.
7. Bring in transfer hose through facility hose port, disconnect tank outlet valve cap and sanitize valve as needed, then hose cap before connection.
8. Ensure agitator is running during pumping to reduce butterfat adhering to tank.
9. Pump milk into tanker truck and shut off pump as soon as the producer tank is empty to avoid sucking air and milk house odors into truck tank.
10. Disconnect and cap transfer hose.
11. Inspect the producer tank for sediment prior to rinsing the producer tank.
12. Rinse the hose port and floor to free of any spilled milk.
13. Perform final facilities inspection and record any information needed to report to the producer or the sample laboratory.
14. Repeat as needed until end of route or tanker tank is full.

End of Route:

1. When no more stops are required, proceed to destination processor.
2. Follow processor's operations protocol to pump milk into storage tanks.
3. Deliver samples to proper laboratory officials and fill out any required documentation required for commercial driver's records.

4. Rinse bulk milk truck tank and transfer equipment, sanitize as needed per truck owner requirements.

Many of the duties of a Bulk Milk Hauler are based on maintaining the quality of milk, while other duties focus on maintaining standards of equipment to ensure the equipment is ready for future use. It could be true that there is a learning curve for juggling so many tasks in the correct order, to a level of standard quality, and in an efficient manner. Also, the duties of visual and odor inspection of raw milk is a skill which puts expert decision making requirements on the bulk milk hauler, which can lead to stressful reporting situations or confrontations with milk farmers or receiving processors.

The Missouri State Milk Board maintains a system for the training and licensing of Bulk Milk Haulers which is in accordance with federal government regulations found in the Grade “A” Pasteurized Milk Ordinance, 2011 Revision. The Missouri State Milk Board conducts testing of Bulk Milk Haulers and issues temporary licenses until the time at which the Bulk Milk Hauler can complete a schooling course. Once this schooling course is completed, the temporary license is updated to a permanent license which is renewed each year. The schooling course must be completed every five years to keep Bulk Milk Haulers current with changes in the industry. Bulk Milk Haulers must also maintain a commercial driver’s license (CDL) which is issued through the Missouri Department of Transportation (MoDOT). This CDL requires its own set of standards and regulations, as well as report protocol for accidents and other issues encountered on the highways of the state.

CHAPTER 3 METHODOLOGY

This chapter outlines the procedures used to test the hypotheses of this study. The purpose and problem are restated, then the hypotheses are listed, followed by the population of study, then the instruments and apparatus used for data collection and analysis. The statistical analysis rationale, and research procedures are found at the end of this chapter.

STATEMENT OF THE PROBLEM

A literature review has shown that there is a need for dedicated bulk milk hauling research that identifies ways to preserve quality by reducing risks of driving accidents. Reduction of driving accidents will increase public safety, save costs to the milk industry as well as government agencies and emergency responders, and reduce risks of low quality milk reaching processors. Low quality or contaminated milk which reaches processors may be mixed with other ingredients and end up causing resultant contamination of products which may require disposal of entire batches, recall of product from stores, or worst case scenario, health issues within the consuming public.

Furthermore, the state of Missouri is in a unique situation in that it has a strong and growing dairy industry, but is not regarded as being in the top 20 milk producing states. Missouri is currently ranked 25th as reported by the United States Department of Agriculture for total milk production with 1.3 billion pounds of milk in 2013. These factors indicate that Missouri may be entering the top 20 states for milk production in the near future, and to do so needs to better understand their situation regarding how milk is being transported within the state.

STATEMENT OF PURPOSE

The purpose of this study is to determine factors that may relate to bulk milk hauling accidents in the state of Missouri, and provide a perspective in understanding the historical data available. The primary focus will fall on historical data available from the Missouri Department of Agriculture's State Milk Board, operating out of Jefferson City, Missouri. Descriptive analysis can be compared and contrasted to other state's findings and also to an overall national level as data is available to do so, in hopes of better understanding the situations that are unique to Missouri, or are shared across state borders. A goal of this research is to identify areas for growth within the data tracking process of reporting bulk milk hauler accidents. As such, this research is a starting point for dedicated analysis of bulk milk transport by truck, specifically within the state of Missouri.

RESEARCH HYPOTHESES

Ho₁ : There is no significant relationship between the number of dairy processors within a region of the state and how many accidents occur within that region.

Ha₁ : There is a significant relationship between the number of dairy processors within a region of the state and how many accidents occur within that region.

Ho₂ : There is no significant relationship between the number of dairy producers within a region of the state and how many accidents occur within that region.

Ha₂ : There is a significant relationship between the number of dairy producers within a region of the state and how many accidents occur within that region.

Ho₃ : There is no significant relationship between how many new bulk milk hauler licenses are given and how many accidents occur each year.

Ha₃ : There is a significant relationship between how many new bulk milk hauler licenses are given and how many accidents occur each year.

Ho₄ : The variable of accident frequency of bulk milk trucks and the variable of load sizes being empty, half-full, or full tanks are not independent.

Ha₄ : The variable of accident frequency of bulk milk trucks and the variable of load sizes being empty, half-full, or full tanks are independent.

POPULATION OF STUDY

This research is based on a data set provided by the Missouri Department of Agriculture's State Milk Board. The historical nature of this study requires that the population be composed of recorded accidents that are held on record with the State Milk Board of Missouri. There is no requirement for instance of personal injury for the accident to be reported, only that the cargo was graded milk being hauled by a person holding a bulk milk hauler license. The records of the Missouri State Milk Board were maintained starting in 2007, and the sunshine request hoped to generate a dataset for a seven year period, starting in 2007 and ending in 2014. Data available proved promising for many of the research questions, and the researcher extracted a sample size of 25 valid data points representing the total accidents reported in the seven year period.

Demographics were not provided in the records, so the population excludes any personal profiles or traceable human factors. The population of study was slightly limited by the fact that

the Sunshine Law data sets only show data tracking for four years of license renewal records, while accident reporting covered the entire seven year span.

INSTRUMENTS, APARATUS, AND DATA COLLECTION

Primary research for the introduction and literature review was performed using various internet searches to identify the key agencies and organizations pertaining to this study. Further scholarly searches were completed using the Online Library Databases provided by the University of Central Missouri, as well as books found in the library facilities. The online searches were stored in digital format on the researcher's computer and backup flash drives. The most useful articles were printed and worked into a research notebook with room for thought formulation and recording important page numbers. Drafts and final formatting were completed using Microsoft Word on the researcher's personal computer.

The Missouri Sunshine Law Open Records Request is a function of the Missouri state government, and was utilized to gather the data set for this historical research. A formal records request was the initial method of contact sent to the Missouri State Milk Board. Emails and telephone conversations took place to clarify the information needed and the legal process. Data was finally presented to the researcher in the form of two Microsoft Excel spreadsheets and a 56 page PDF document. The integrity of the original documents is maintained by backup storage on a USB storage device, and Microsoft Excel has been utilized to manipulate the data into useful groupings and categories saved in separate locations. The researcher poured over the 56 page PDF document and extracted the information, then coded the data into an Excel spreadsheet.

The resulting data set was analyzed using Microsoft Excel 2013 via the statistical analysis package. This program was accessed via the researcher's home computer.

RESEARCH PROCEDURE

The first order of business for this study was to conduct a literature survey of the current body of knowledge available on the subject. The literature review followed and helped set the scope of the study and formulate the research questions. The research questions were then adjusted into research hypotheses once it was clear what sort of data would be available for the defined population. These hypotheses were reviewed with the thesis committee and the type of study was defined to be a historical descriptive analysis.

During research, it was discovered that the state of Missouri embodies a commitment to the openness of government, and this can be seen by chapter 610 of the Revised Statutes of Missouri. This chapter is known as the Missouri Sunshine Law and makes meetings, records, votes, actions, and deliberations of public governmental bodies open to the public. The researcher filed a formal request for information pertaining to bulk milk truck accidents, see Appendix A, and thus started a dialogue with the Missouri State Milk Board which provided the data set utilized in this study. A request was sent to the University of Central Missouri Human Subjects Institutional Review Board for the status of a non-human subject study, as the information was of public record and of historical nature.

Initial descriptive analysis of the data available presented a few interesting results which could be represented by graphical organization. The first steps to organizing the data involved mapping out every accident location across the state of Missouri. This provided a new

perspective to compare the information to other available maps, such as Highway Patrol jurisdictions, and locations of producer farms and processor plants. Other data showed possible initial relationship between variables by use of histograms and other graphs. Having a limited amount of data on certain aspects of each accident lead to a further research questions regarding the completeness of recorded information, and to what purpose are these records kept. A further request of more detailed information regarding driver place of origin, status of license whether temporary or permanent, and other demographics was made. The second request proved to fall into records not kept by the Missouri State Milk Board, so did not fall into the scope of this study. Data analysis proceeded, with the current data set and scope of research.

DATA ANALYSIS

The data set was grouped into different files using Microsoft Excel 2013, then individually analyzed using Microsoft Excel 2013 statistical analysis package. The results section of this study discusses what was found in the descriptive and statistical analysis of the data, and the conclusions of this study helped to present the end result of the study and direction for future research. Pearson's r Correlation was used to identify the relationships between variables with a confidence level of 0.01 alpha. Chi Square testing was used to analyze whether certain variables were independent of each other, or if there could be an observed tendency for related occurrence.

CHAPTER 4 RESULTS

It is the purpose of this study to determine factors that may be related to bulk milk hauling accidents in the state of Missouri based on the historical data available. It was discovered that the data collected falls into a category of accountability, and serves this purpose within the Missouri State Milk Board. The idea of accountability in this case is that records are kept in order to maintain traceability of milk as it is transported from producer to processor. The data, as seen in this view, is then currently intended for purposes of tracking and not for analysis for improvements. With this in mind, the researcher needed to create a fresh perspective to start to look at the information available, as provided by the Missouri State Milk Board.

ACCIDENT RECORDS ON FILE

From the 56 pages of provided records, data was extracted to create the profiles of 25 bulk milk hauling accidents which occurred between the dates of April, 2007, and April, 2014. This span of seven years covers the entirety of records currently held by the Missouri State Milk Board. The records were kept in hard document form, many of which were hand written notes filling out the accident report questions list found on page three of the Standard Operating Procedures for Milk Truck Accident guide produced by the Missouri State Milk Board. The accidents reports did not have a standardized system for answering the questions, and were sometimes limited the reporting a source's knowledge over the telephone. Sometimes, a police report was filed in conjunction with the records to provide more detailed information, yet again, there was not standardized system for answers. This being said, only limited data was available for extraction that was present in all 25 profiles for comparison.

The accident profiles presented seven consistent variables which the researcher was able to extract and code into a database. These variables included the time, day, month, and year of the accident, as well as the general load size, whether it was salvageable, and the location. The charts presented below show a descriptive representation of the accident profiles. Figure 1 shows a daily time quadrant representation of each recorded accident over the seven year span. Figure 2 shows the load size of each accident and tells whether the milk was salvaged or not. Figure 3 presents the number of accidents per region within the state. Regions were based on Highway Patrol jurisdiction, as this data was available as accountability record on the bulk milk accident reporting documents. A map depicting region location within the state can be seen in Figure 5 later in this chapter.

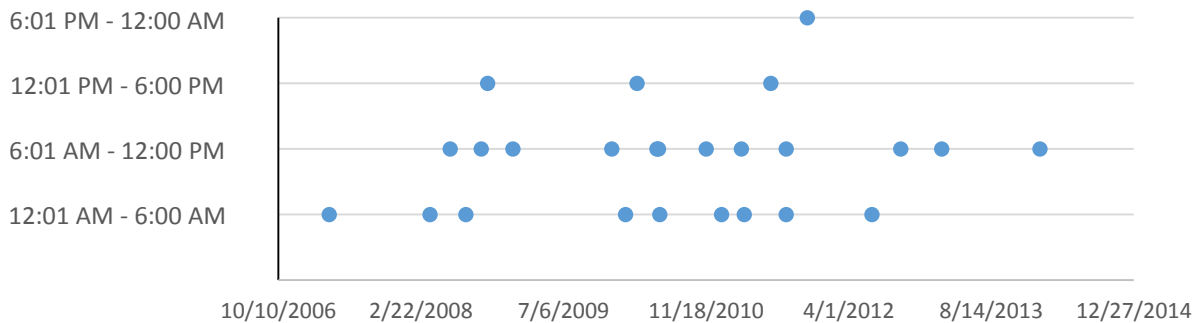


Figure 1. Scatter Plot of Time and Quadrants of Total Accident Occurrence in Missouri by Date

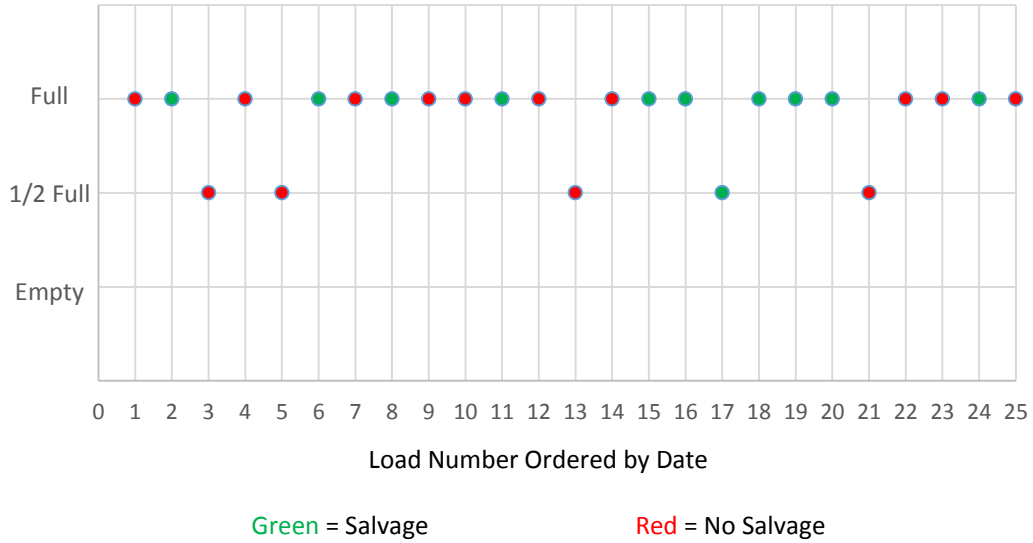


Figure 2. Scatter Plot of Load Size of Accidents with Salvage Status

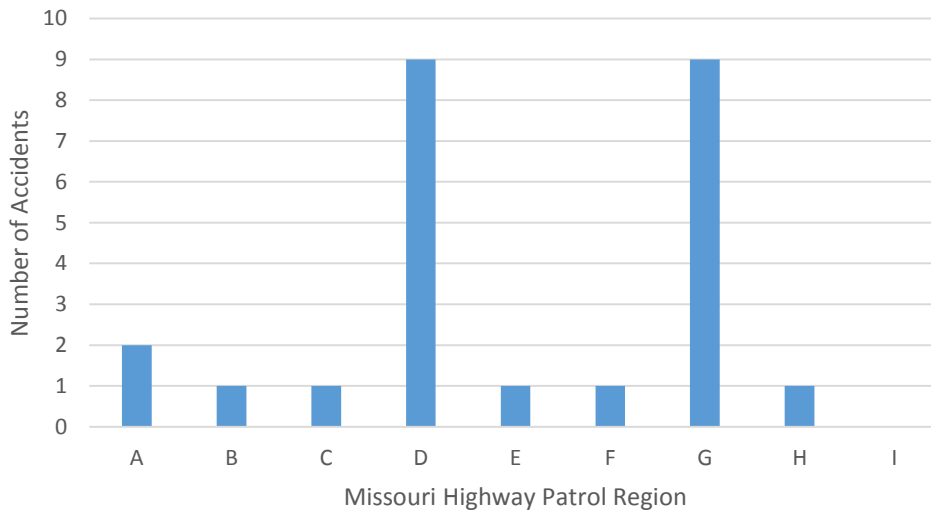


Figure 3. Histogram of State Region vs Number of Accidents
 Note: Reference Figure 5 for a map of regions.

MISSOURI MAP ANALYSIS

With this descriptive foundation in mind, further research was conducted to uncover comparable data from other sources outside the Missouri State Milk Board records. The variable which stood out as being most useful for comparison to outside information was the locations of the accidents. To further understand this variable, the researcher plotted each accident onto a state highway map of Missouri, as seen in Figure 4.

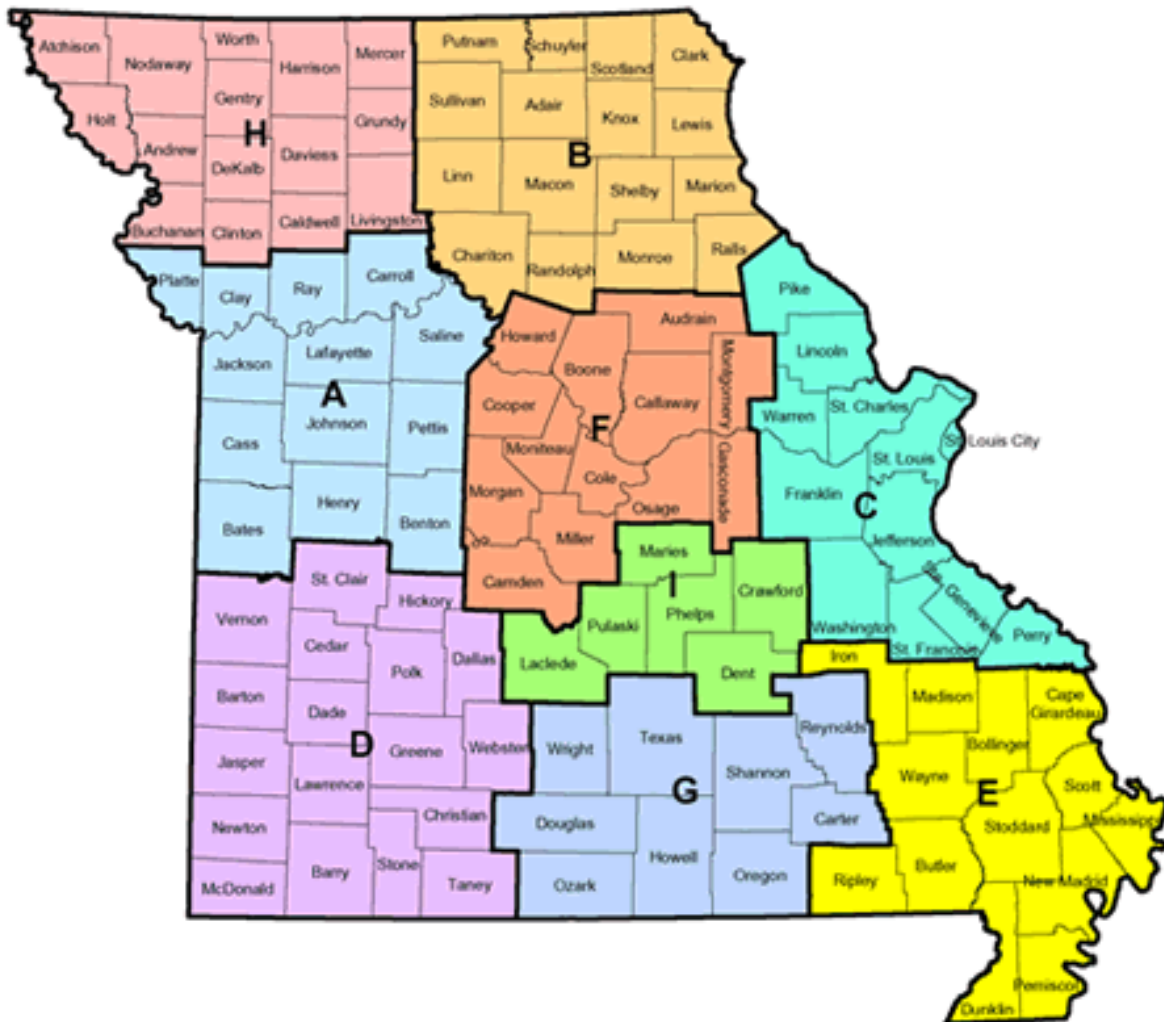


Original Map: Geology.com

● Accident Locations (25)

Figure 4. Bulk Milk Hauling Accidents in Missouri, 2007 to 2014

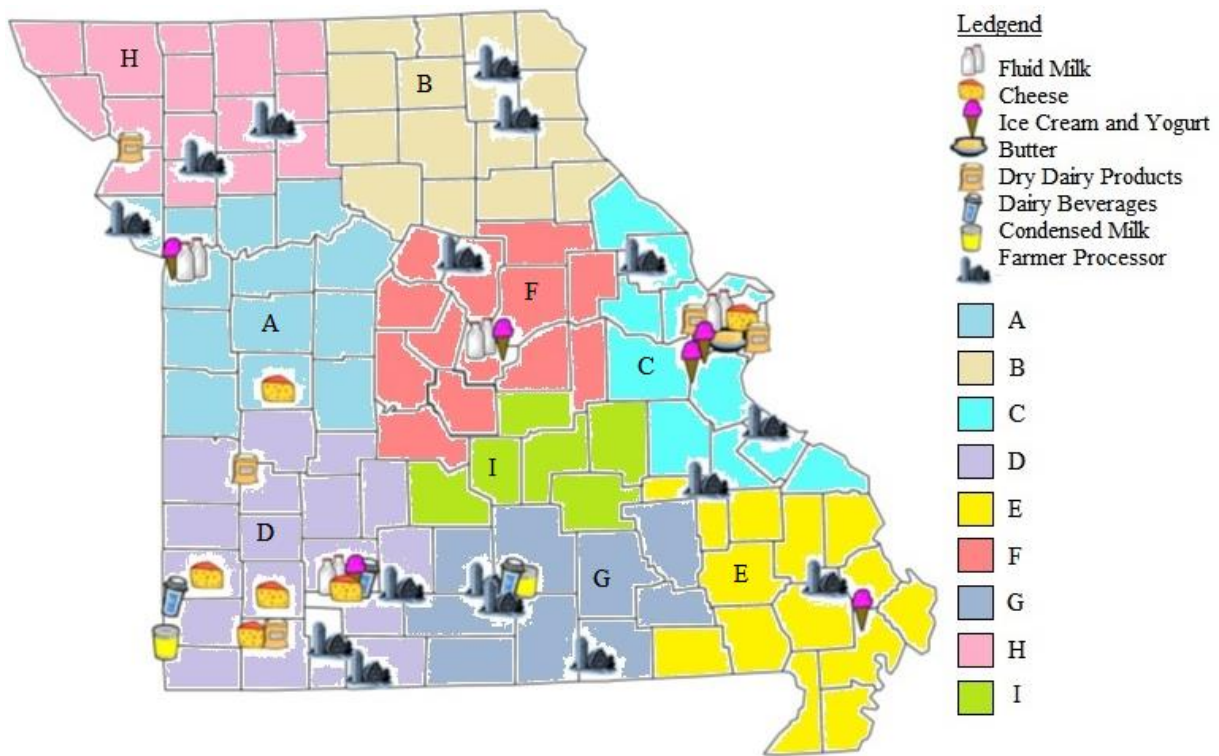
The map in Figure 4 also contained county line indications, which lead to a further ability to understand the distribution of accidents. Each accident report was filed with an associated police department or highway patrol office. In order to segment the State of Missouri to better understand the accident distribution, a map of highway patrol jurisdiction was discovered, and presented in Figure 5.



Wikipedia, Missouri State Highway Patrol

Figure 5. Missouri State Highway Patrol Jurisdictions

With these two maps, a set of nine regions was created and coded into the database. The researcher then searched for further information about the geographic distribution of the Missouri dairy industry, and found two more useful maps. The first, as seen in Figure 6, is a map of locations for dairy processors, with indicating lines for county borders. This map was color coded to represent the nine regions identified previously, and the number of dairy processors per region was coded into the data base.



Original Map: Horner & Milhollin (2013)

Figure 6. Milk Processor Locations in Missouri

Comparing these four maps shows some immediate indication that south western Missouri is a major hub for the dairy industry in that it has a concentration of dairy farmers and processors, and also has the highest reported bulk milk hauler accident rate over the span of seven years. In order to test the hypothesis that the variables were indeed connected, and show a significant trending relationship, the researcher used a Pearson r test for correlation. This statistical tool was chosen because while the maps gave a visual indication of a relationship, the histograms (Figures 8 & 9) of the data did not paint as clear of a picture. For example, region C near St. Louis appeared to go against the relationship with only a single accident yet had the second highest density of dairy processors, as shown in Figure 8.

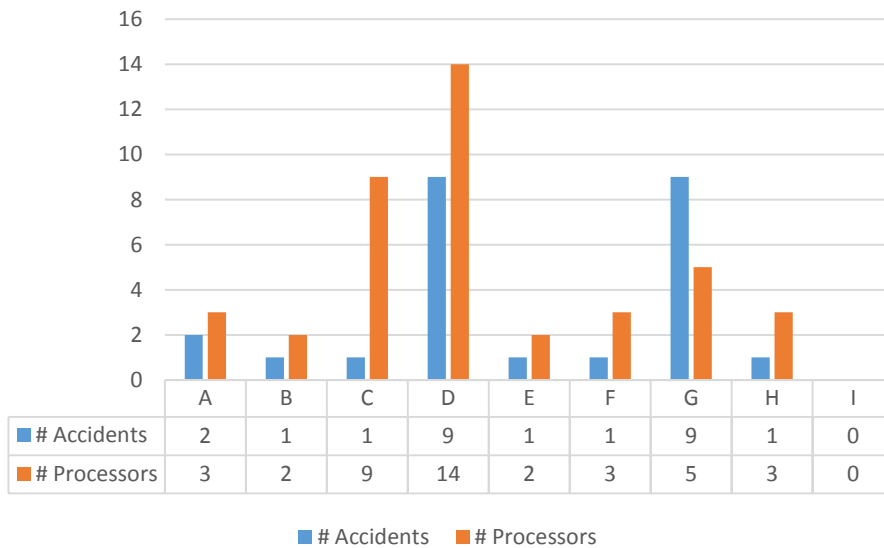


Figure 8. Histogram of Accidents and Processor Totals Per Region

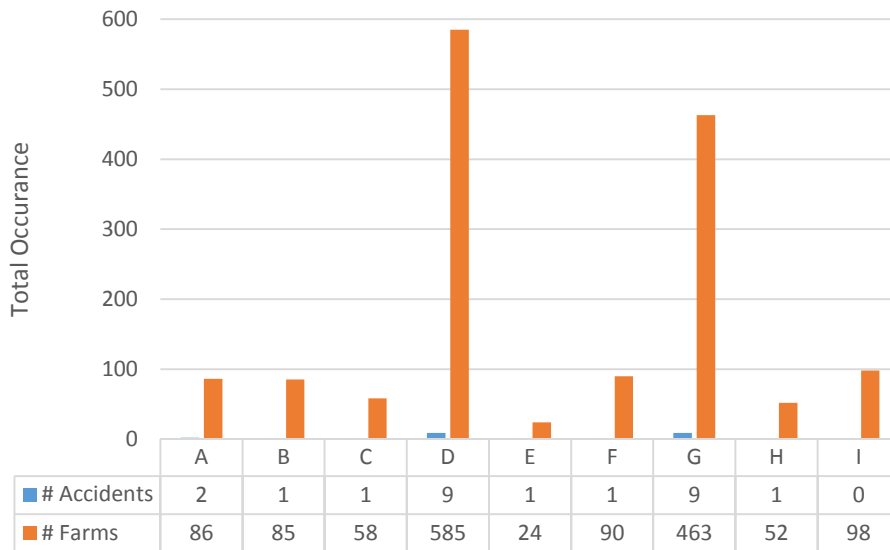


Figure 9. Histogram of Accidents and Producer Totals Per Region

The data in question was isolated from the coded database to form Table 2, seen below, then Microsoft Excel's correlation formula was used to run the statistical calculations and produce a correlation coefficient. This coefficient is between -1 and 1, and indicates the strength of the tendency for the variables to move together. A positive coefficient indicates a positive relationship, while a negative coefficient indicates a negative relationship. It is generally assumed that coefficient values greater than 0.5 are of high correlation, while values above 0.3 are of medium correlation (Andale, 2012). The same applies for negative relationships. This statistical test can be seen in Figure 10, where the correlation coefficients can be seen in matrix form. For actual hypothesis testing, the researcher used the population size to determine the actual thresholds for significance.

Table 2

Sorted Region Data with Associated Pearson's r Correlation

<u>Region</u>	<u># Accidents</u>	<u># Processors</u>	<u># Accidents</u>	<u># Producers</u>
A	2	3	2	86
B	1	2	1	85
C	1	9	1	58
D	9	14	9	585
E	1	2	1	24
F	1	3	1	90
G	9	5	9	463
H	1	3	1	52
I	0	0	0	98
Correlation Coefficient	0.665		0.970	

Table 3

Pearson's r Correlation Matrices for Regional Accidents

	<u># Accidents</u>	<u># Processors</u>		<u># Accidents</u>	<u># Producers</u>
<u># Accidents</u>	1		<u># Accidents</u>	1	
<u># Processors</u>	0.665	1	<u># Producers</u>	0.970	1

The results of the Pearson's r Correlation shows that both correlation coefficients are above 0.3, which means that there is a positive relationship and that there exists at least a medium effect on the variable relationship. The correlation coefficient of 0.665 is just above the threshold value for high correlation, indicating that the relationship of total processors vs accident rates is not entirely weak. There could be a strong relationship of total producers vs accident rates, as these variables produce the correlation coefficient of 0.970. This value puts the relationship into a large effect range. With this statistical data, the researcher is ready to

approach hypotheses 1 and 2 of this study. It is interesting to notice the data for Region C indicates only one accident occurred, yet nine processors exist. This is the second highest concentration of processors falling only behind Region D which contains 14 processors. This data is an indication why there is a much stronger relationship between the number of producers and accidents within a region than there is a relationship for the number of processors and accidents within a region.

HYPOTHESIS ONE & TWO TESTING

$H_{01} (\rho = 0)$: There is no significant relationship between the number of dairy processors within a region of the state and how many accidents occur within that region.

$H_{a1} (\rho \neq 0)$: There is a significant relationship between the number of dairy processors within a region of the state and how many accidents occur within that region.

By use of Pearson's r Correlation testing, it was shown that a positive relationship does in fact exist between the number of dairy processors within a region of the state and how many accidents occur within that region. The relationship presents a coefficient value of 0.665, results in a t -value of 4.27, which is used in a two tailed probability test giving a p -value below the significance level of 0.01. The researcher can defend the resultant relationship at 0.01 significance and therefore reject the null hypothesis.

In similar suit, we look at Hypothesis 2:

$H_{02} (\rho = 0)$: There is no significant relationship between the number of dairy producers within a region of the state and how many accidents occur within that region.

Ha₂ ($\rho \neq 0$): There is a significant relationship between the number of dairy producers within a region of the state and how many accidents occur within that region.

By use of Pearson's r Correlation testing, it was indicated that a significant relationship can be supported between the number of dairy producers within a region of the state and how many accidents occur within that region. The relationship presents a coefficient value of 0.97, results in a t -value of 19.14, which is used in a two tailed probability test giving a p -value below the significance level of 0.01. The researcher can then reject the null hypothesis, and defend the result that a significant relationship does exist between the variables. The data supports the notion that with more producers and processors in an area, it is more likely that accidents would occur in that region.

LICENCING ANALYSIS

Included in the data available from the Missouri State Milk Board was the record of professionals holding bulk milk hauler licenses. This list included a wealth of information about current total licenses held, total permanent licenses held, and total temporary licenses held. Also, the data set included an indication of new license attainment. Sadly, the historical data on licensing was only kept on spreadsheet databases starting in 2012, so it is difficult to make any judgments on the connection of this data to the data extracted from accident reporting. Figure 10 presents the available trending data in the form of a histogram. From this graph, we can see some interesting trends indicating an increase of number of temporary licenses, and a decrease in the number of permanent licenses. It is also interesting to note that the years 2012 and 2013 experienced a high number of canceled licenses, 44 and 43 respectively. Despite the contrast of

temporary versus permanent licensing, the overall total new licenses per year has shown an increase over the four year period.

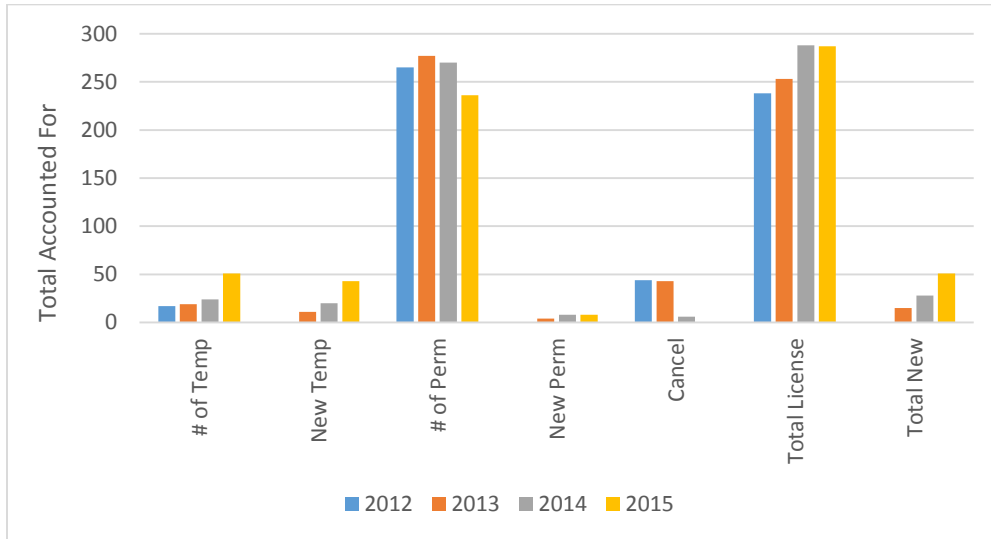


Figure 10. Histogram of Bulk Milk Hauler Licensing Spanning 2012 to 2015

When looking at the available data, we are provided with only four data points that are useful in conjunction with licensing data, and it should be noted that licensing leads accident data in acquisition. This means the scope of licensing operations extends into the forthcoming year, in this case 2015, and therefore there is no historical data available to analyze for this situation. It must also be noted that at the point in time this chapter is being written, there are five months remaining in the year 2014 which could provide further accident record reporting. It is with this view point that the researcher approaches the following research question of hypothesis three: Does a relationship exist between how many new licenses are given and how many accidents occur each year? Pearson's r tests were run for situations including a span of 2012-2014. The

resulting calculations provided the comparison of the following matrix figures. Table 4 shows this comparison on a premise of accident rate versus temporary license, with an accompanying histogram for visualization in Figure 11. Table 5 shows this comparison on a premise of accident rate versus permanent licenses, with an accompanying histogram for visualization in Figure 12. Table 5 shows this comparison on a premise of accident rate versus total licenses, with an accompanying histogram for visualization in Figure 13.

Table 4.

Pearson's r Correlation for Total Accidents vs Temporary and New Temporary

2012-2014	# of Accidents	# of Temp	New Temp
# of Accidents	1		
# of Temp	-0.720	1	
New Temp	-0.893	0.955	1

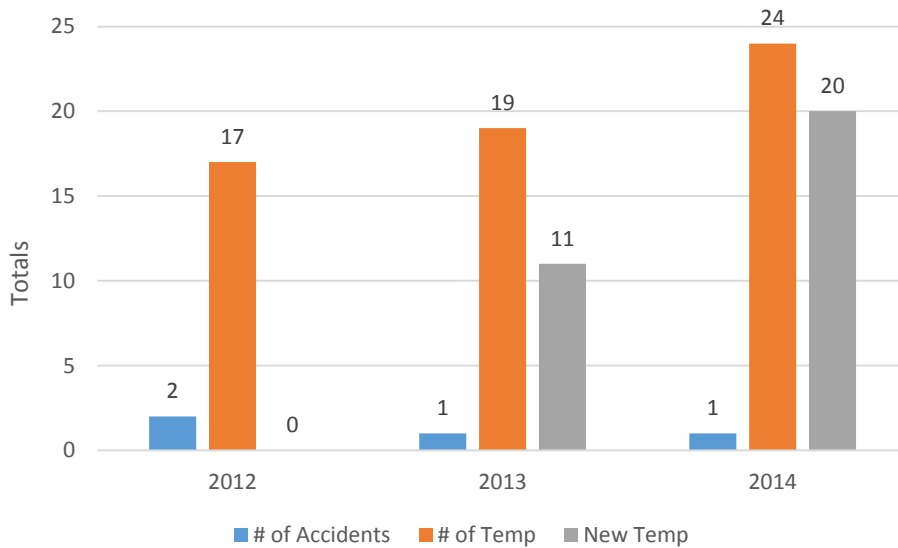


Figure 11. Histogram of Total Accidents and Temporary Licenses Per Year

With the data charted in Figure 11, and the associated correlation coefficients from table 4, we can see that a trend may exist. The trends include a positive relationship between the number of new temporary licenses and total temporary licenses, this relationship is supported by a correlation coefficient of 0.955, which indicates a large effect of relationship in a positive fashion. A negative relationship exists between both temporary and permanent licenses totals versus accident totals, because as license totals increases, the number of accidents decreases. Total temporary licenses have a more gradual increase over the three year span as compared to total new temporary licenses, this explains the difference in the correlation coefficients, with a -0.893 coefficient for new temporary vs accidents, and a -0.720 coefficient for total temporary vs accidents.

Table 5

Pearson's r Correlation for Total Accidents vs Permanent and New Permanent

<i>2102-2014</i>	<i># of Accidents</i>	<i># of Perm</i>	<i>New Perm</i>
<i># of Accidents</i>	1		
<i># of Perm</i>	-0.814	1	
<i>New Perm</i>	-0.866	0.415	1

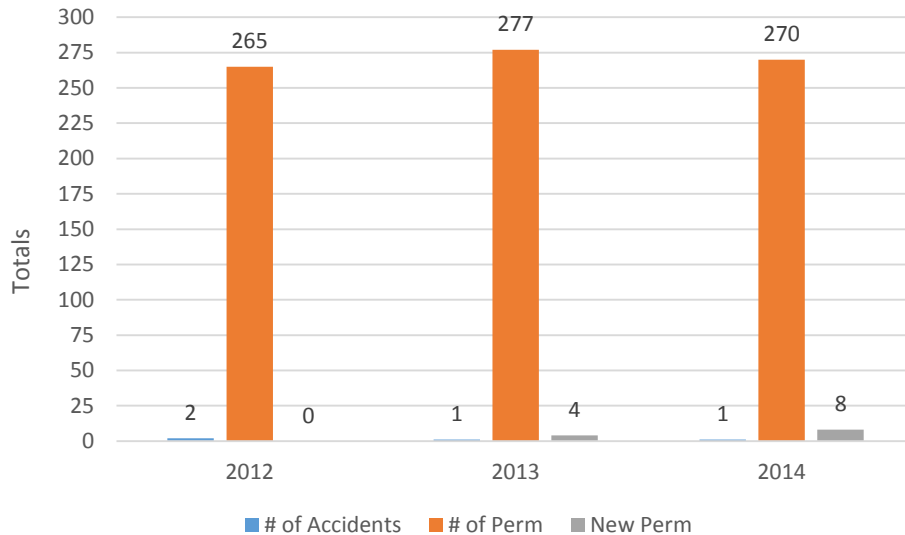


Figure 12. Histogram of Total Accidents and Permanent Licenses Per Year

The data for total accidents, total permanent licenses, and total new permanent licenses shows a similar situation as seen previously with temporary licenses. There is a positive relationship between total new permanent licenses and total permanent licenses, while a negative relationship exists between licenses totals and total accidents. It is interesting to note that the positive relationship is only at a medium to low effect level with a correlation coefficient of only 0.415. This could be because in year 2014, total permanent licenses was lower than in year 2013, yet still showed an increase over year 2012. Accidents versus total new permanent licenses has a coefficient of -0.866, while accidents versus total permanent licenses has a coefficient of -0.814. Both of these coefficients provide a reasoning for a medium to large effect on the relationship, and are in a similar range and ratio as compared to temporary license results.

Table 6

Pearson's r Correlation for Total Accidents vs Total and New Licenses

2012-2014	# of Accidents	Total License	Total New
# of Accidents	1		
Total License	-0.731	1	
Total New	-0.886	0.964	1

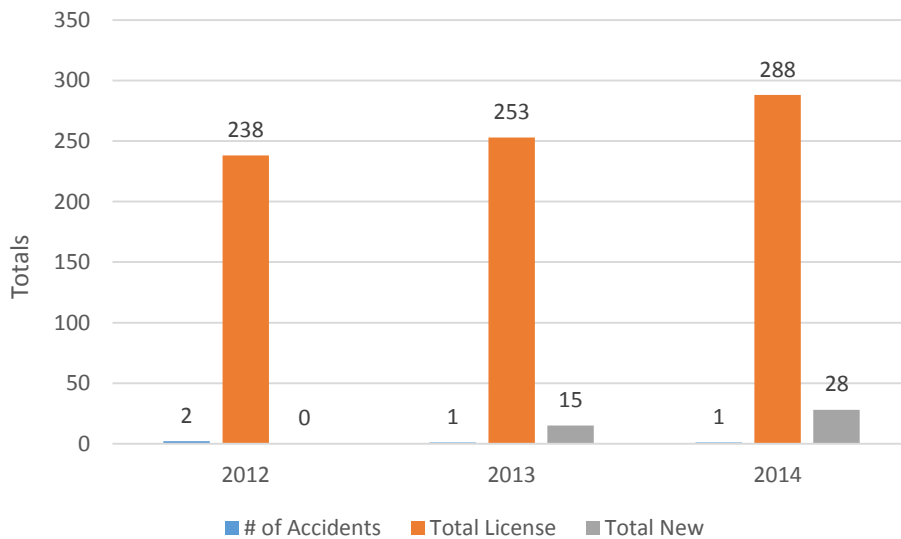


Figure 13. Histogram of Total Accidents and Total Licenses Per Year

It is safe to say that the trends reflected in temporary licensing situations and permanent licensing situations are reflected in the total licensing situation. The accident totals remain the same, which produces a negative relationship with both totals licenses and new licenses showing a correlation coefficient of -0.731 and -0.886 respectively. This lends to the idea that as the

number of licenses go up, the number of accidents go down. The positive relationship between new licenses given and total licenses on record is maintained with a large effect correlation coefficient of 0.964.

HYPOTHESIS THREE TESTING

H_0 ($\rho = 0$): There is no significant relationship between how many new bulk milk hauler licenses are given and how many accidents occur each year.

H_a ($\rho \neq 0$): There is a relationship between how many new bulk milk hauler licenses are given and how many accidents occur each year.

By use of Pearson's r Correlation Testing, it was shown that this null hypothesis can be rejected as the p -value falls below the significance level of 0.01, yet some speculation exists due to the data only covering two full years. A negative relationship was shown after analysis of the available data. However, the researcher must view the null hypothesis as the most tenable hypothesis based on the data available because of the lack of completeness of the data set.

ACCIDENT FREQUENCY AND LOAD SIZE

Looking at the 25 accident profiles, it became clear that the load size of each tank was recorded and could be compared to accident frequency. When looking at the simple histogram of Figure 14, comparing the accident rate of each load size: empty, half full, and full, it became clear that a relationship between the variables could exist. The data is heavily shifted toward the load size of full.

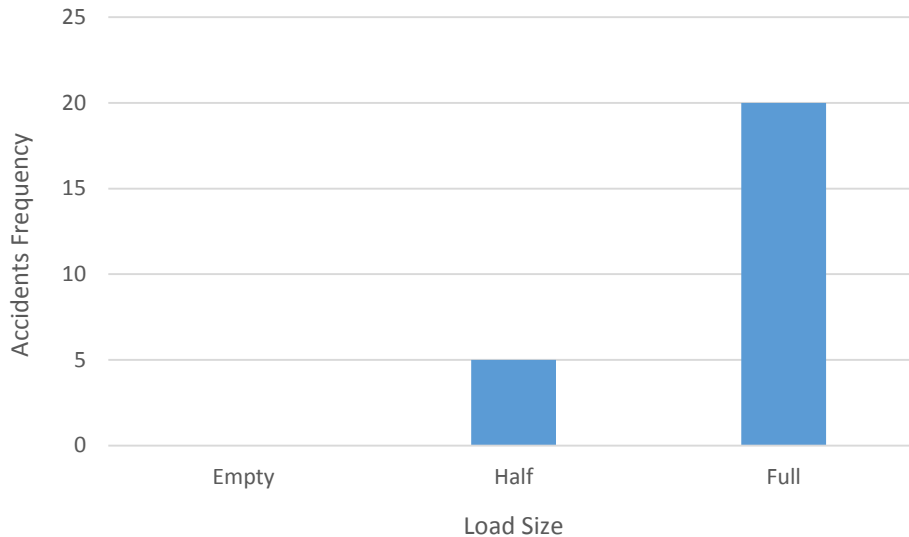


Figure 14. Histogram of Total Accidents Per Load Size

Seeing this histogram, the researcher continued the analysis of the data with a Chi Square testing for independence. This test would determine if the variables of accident frequency and load size were isolated and independent, or if they were indeed connected in some way. It was determined that out of the 25 accident incidents, there could be a random occurrence of the load size if the load size did not play a role in the accident. To represent this, the expected outcome for randomness was determined. The expected results and the actual observed results are shown in Table 7.

Table 7

Expected and Observed Accident Frequency Per Load Size

Load Size	Load Code	Expected	Observed
Empty	1	8.33	0
Half	2	8.33	5
Full	3	8.33	20

With this distinction of occurrence, the formula for Chi Square was used to calculate the result for comparison to the P-value 9.210, which is associated to two (2) degrees of freedom and a critical value of 0.01. The Chi Square formula resulted in a value of 26.010, which exceeds the P-value for this situation. Exceeding the P-value indicates that the observed occurrence was indeed different than the expected results, and it can be said there is a 99% certainty that the variables are not independent. It can be said that the accident frequency and the load size are not independent of each other.

HYPOTHESIS FOUR TESTING

H_{04} ($\rho \leq 9.210$): The variable of accident frequency of bulk milk trucks and the variable of load sizes being empty, half-full, or full tanks are not independent.

H_{a4} ($\rho > 9.210$): The variable of accident frequency of bulk milk trucks and the variable of load sizes being empty, half-full, or full tanks are independent.

The data provided means to test this hypothesis using the Chi Square formula for independence testing. With a resultant calculations exceeding the Chi Square P-value for 0.01 significance, we can reject the null hypothesis with a 99% certainty that the load size of a milk hauling truck is not independent from the accident frequency occurrence. The researcher then is able to defend the alternate hypothesis that the variable of load size of a milk hauling truck is not independent from the accident frequency, and full trucks are more likely to be in an accident.

Table 8

Summary of Hypothesis Testing

hypothesis	alpha	df	p value / chi square	result
Ha ₁	0.01	23	0.000287	reject null
Ha ₂	0.01	23	< 0.000001	reject null
Ha ₃	0.01	23	< 0.000001	cannon reject null ¹
Ha ₄	0.01	2	26.010 ²	reject null
1. Ha ₃ rejected due to insufficient data with only two recorded years. 2. Chi Square test exceeds the critical value of 9.210 for 0.01 significance.				

CHAPTER 5 DISCUSSION, CONCLUSIONS, AND RECOMENDATIONS

This chapter is a culmination of the study, and will present how the findings within the population of study compare to the research hypotheses by referencing the literature review. The purpose of the study will be presented to maintain the focus of discussion, and the stakeholders will be referenced to provide some perspective of significance.

The purpose of this study is to determine factors that may be related to bulk milk hauling accidents in the state of Missouri, and provide a perspective in understanding the historical data available. The primary focus will fall on historical data available from the Missouri Department of Agriculture's State Milk Board, operating out of Jefferson City, Missouri. A goal of this research is to identify areas for growth within the data tracking process of reporting bulk milk hauler accidents. As such, this research is a starting point for dedicated analysis of bulk milk transport by truck, specifically within the state of Missouri.

This study presents a current state perspective through the viewpoint of data from the Missouri State Milk Board. Based on historical data held by state government, this perspective provides a realistic view of what is deemed important information to track for the purposes of the State Milk Board's operations. It is important to note that this is the entirety of information kept since the start of data tracking in 2007. It is the goal of the State Milk Board to provide safe dairy products to consumers while ensuring fair market prices within the industry.

By limiting the data to a single state, the primary stakeholders on the subject are also limited to the producers, transporters, and processors operating within the state. Producers could

use this information when selecting destinations for their milk and selecting business partners and customers. Transporters could use this information to identify areas of risk in order to undertake extra precaution during certain situations. Processors could use this information to identify risk in their supply chain, or dedicate resources to help enable better operations within the supply chain. Other stakeholders could include producers, transporters, and processors operating out-side the state but looking to expand their operations to include regions of Missouri. A further removed group of stakeholders would be other states with similar milk production statistics which are looking for information to benchmark themselves in studies of their own.

REGIONAL CONSIDERATIONS

Research Questions:

1. Is there a relationship between the number of dairy processors in a region within the state and the number of accidents seen within that region?
2. Is there a relationship between the number of dairy producers in a region within the state and the number of accidents seen within that region?

These research questions help to define the scope of the study even further, and enable a visual representation of how and why milk moves across the State of Missouri. When looking at maps, many factors come into play depending on the type of map. These factors could show topographical features, highway systems, county borders, regional jurisdictions, populations, and economic values to simply name a few purposes of maps. In this study, the choice of map

was dependent on how the data set could interact with the information presented on the map, while keeping an objective perspective and maintaining the scope of the study. It was decided that the regional boundaries of Highway Patrol Jurisdiction would be useful as a foundation map for segmenting the state into regions. The Highway Patrol of Missouri, as well as other policing agencies are important stakeholders that could benefit from the information within this study, and this information can be more useful if it is presented in a format which they are familiar.

In the literature review we learned of the three year large truck crash causation study conducted by the FMCSA, in which environmental factors were identified as a secondary consideration as compared to driver factors that were the key influence factors in large truck crashes (FMCSA, 2005). For this reason, maps were not used to determine environmental factors such as topography or weather patterns. Instead, the maps are showing the dispersion of dairy producers and dairy processors in hopes to identify with influences on driver factors. For example, as identified by the FMCSA, a driver factor with a 21.6% occurrence rate is that the driver was Unfamiliar with Roadways, driving on the roads less than six times in six months (2005). By looking at the regional dispersion of processors versus producers on the maps, it can be seen that producers are present in more areas across the state, and in greater number. The duties of a Bulk Milk Hauler include frequenting dairy producers on their route before continuing to a processing facility. With so many dairy producers, it is conceivable that a bulk milk hauler may attain fullness of their tanker at varying locations depending on that day's route, but then travel to the same usual processing facility. This produces a variation in the driving route, and therefore may be an indication that the driver is unfamiliar with the roadway.

Regression testing was conducted in order to gain a descriptive analysis of the distribution of dairy producers versus accident rates as well as the distribution of dairy processors versus accident rates. Results of the regression testing showed that there exists a positive relationship between both sets of variables. It is also noted that the relationship between the concentration of dairy producers and accidents was at a highly significant effect level, while the relationship of processors and accident rates was at a less significance level, yet still exceeded the value for 0.01 significance. In comparison with the idea presented above that driver accident rates increase with unfamiliarity of roadways, we can imagine the situation where the route between farms has a high variability, but when the tank is full of milk, there is a common route to reach that leads to the processor. This situation could account for the increased accident rates within areas with a higher population of dairy producers. It is interesting to note that by comparing Figure 9 with Figure 11, it can be seen that less than 300 bulk milk haulers service well over 1,000 dairy producing farms. This ratio could be another indicator that drivers may be unfamiliar with certain roadways leading to and from certain dairy farms.

LICENSING CONSIDERATIONS

Research Question

3. Does a relationship exist between how many new licenses are given and how many accidents occur each year?

This research question served the purpose of trying to identify the relationship between new bulk milk hauler license holders and the frequency of accidents. It was speculated that with the highly regulated and quality dependent skill set required of a bulk milk sampler, a degree of

stress or pressure could influence the driving performance of the bulk milk hauler. New bulk milk haulers could have a more difficult time dealing with these pressures, and an increase in accident rates could have been seen with an increase of new licenses seen. In comparison with the factors that influence large truck crashes, leading causes of crashes that new bulk milk haulers could be prone to include traveling too fast for conditions, fatigue, work-related pressure, external distraction factors, and being unfamiliar with vehicle. The literature review showed the following percentages for each of these factors' occurrence in a three year study: traveling too fast for conditions (22.9%), fatigue (13.0%), work-related pressure (9.2%), and being unfamiliar with vehicle (6.5%) (FMCSA, 2005).

To the surprise of the researcher, the exact opposite relationship was found within the data available. There was a medium to large significance in the relationship in the negative direction. As the number of new bulk milk hauler licenses increased, the accident frequency decreased. Considerations formulated after this finding include the fact that the Commercial Driver's License required to drive a Class A vehicle could be held for many years prior to attaining the bulk milk hauler license. Simply earning a new bulk milk hauler license does not mean the driver is new to trucks, or even driving under stress and work-related pressures.

It is important to note that a negative relationship was shown after analysis of the available data. However, the researcher must view the null hypothesis as the most tenable hypothesis based on the data available because of the lack of completeness of the data set.

LOAD CONSIDERATIONS

4. Is the accident frequency related to load sizes of empty, half-full, or full tanks?

Looking at the 25 accident profiles, it became clear that the load size of each tank was recorded and could be compared to accident frequency. The load size of a tanker truck is important because of the immense volume of fluid often held in a full load. It was observed in the data set that it was not uncommon for a milk tanker to carry upwards of 50,000 pounds of milk in a full load. When looking at the FMCSA study of 2005, certain accident cause factors could be connected to the load size of a bulk milk tanker truck. Driver factors including traveling too fast for conditions, which would increase safe breaking distances, especially when carrying a full load, as well as inadequate evasive action as a full load can reduce the agility of a large tanker truck. Vehicle factors that have a large occurrence rate in large truck accidents include brake failure or being out of adjustment (FMCSA, 2005). Brake failure can be catastrophic, especially when carrying massive loads approaching 50,000 pounds of milk. These large loads could also easily surpass the safety threshold of an out of adjustment set of brakes.

Another perspective for load size versus accident rates of bulk milk hauling takes into consideration the fact that a full truck is often found at the end of a route. This means that the bulk milk hauler has most likely made several stops at different dairy farms in order to fill the entire tank. At the end of a day of work, it can be assumed that certain driver fatigue factors, or time related pressures could come into play. The presence of these driver related factors increases the risk of large truck crash occurrence as shown by the FMCSA (2005).

It was discovered that the population of study presented data which supported the relationship of load size to accident frequency. The testing of the hypothesis showed that the variables of load size and accident frequency can be classified as not independent.

RECOMMENDATIONS OF STUDY

This descriptive study has served the purpose of presenting the current historical trends found within the bulk milk hauling industry in the State of Missouri. The population of study was limited by the scope of data available from the Missouri State Milk Board, who seeks to provide an administrative approach to the data. This administrative approach represents the idea that data is currently being kept for traceability and accountability purposes. It was the goal of this research to identify areas for improving the current accident reporting situation to better support the reduction of risk in the industry. An improvement of this nature could benefit the industry as a whole, as the information would be more widely available to the industry, rather than being found only within the records of private companies.

From the data presented in this study, statistically identified defenses of several alternate hypotheses show that there is a relationship of the independent variables of dairy producer dispersion, dairy processor dispersion, and load size, to the dependent variable of accident rates. Using this information as a starting point, it is recommended that further research be conducted into the connection of these independent variables to the crash causing factors identified by the FMCSA study of 2005. This approach could result in identifying actionable changes to the current industry in order to reduce the risk of accident occurrence.

It is the opinion of the researcher that preventative action could be employed within the current bulk milk hauling licensing program. Currently, the entirety of licensing focuses on the duties of the bulk milk hauler as a sampler and dairy professional. An increase in training could

include areas focused on driving considerations specific to a bulk milk tanker. Perhaps it is this joining of industries which is required for further research. As a dataset of overall large truck accident rates within the State of Missouri could be compared to the dataset of bulk milk hauling.

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APPENDIX A
SUN SHINE REQUEST LETTER CORRESPONDENCE

ORIGINAL REQUEST LETTER

Dear Mr. Warrick:

Under the Missouri Sunshine Law (RSMo Chapter 610), I request in electronic form a copy of your agency's State Milk Board producers database for the span of January 1, 2007 to January 1, 2014.

I understand that the data is stored in format. Please provide the data to me in that format or in Microsoft Excel. In addition, I request copies of any documentation that I'll need to understand the data.

Please contact me if you have any questions about my request. I will be happy to work with you to fill this request quickly. Feel free to contact me at my phone number, which is listed at the head of this letter.

You can email the files to me at: whb85970@ucmo.edu

If you deny any or all of this request, you are required to do so in writing. In your letter, please cite the laws that allow you to deny any information.

I look forward to your response within three working days, as required by the Sunshine Law.

Sincerely,
William Benedict

RESPONSE TO ORIGINAL REQUEST LETTER



DEPARTMENT of AGRICULTURE
STATE OF MISSOURI
JEFFERSON CITY

JEREMIAH W. (JAY) NIXON
GOVERNOR

*Serving, promoting and protecting the agricultural producers, processors
and consumers of Missouri's food, fuel and fiber products.*

RICHARD FORDYCE
DIRECTOR

April 10, 2014

William Benedict

Sent via e-mail: whb85970@ucmo.edu

RE: Sunshine Request – State Milk Board producer's database for 01/01/2007-01/01/2014

Dear William:

This will acknowledge the receipt of your April 10, 2014 request for records under the Sunshine Law, Chapter 610, Revised Statutes of Missouri. Under the Missouri Sunshine Law, all open records maintained by the Missouri Department of Agriculture will be made available to you.

The Department is reviewing your request for records that are responsive to your request.

You should expect to hear from the Department on or before April 25, 2014.

Sincerely,

A handwritten signature in blue ink that reads "C. Klick". The signature is written in a cursive, flowing style.

Caryn Klick
Executive Assistant to the Director

UPDATED RESPONSE AFTER CLARIFIED REQUEST



DEPARTMENT of AGRICULTURE
STATE OF MISSOURI

JEFFERSON CITY

*Serving, promoting and protecting the agricultural producers, processors
and consumers of Missouri's food, fuel and fiber products.*

JEREMIAH W. (JAY) NIXON
GOVERNOR

RICHARD FORDYCE
DIRECTOR

July 22, 2014

William Benedict

Sent via e-mail: whb85970@ucmo.edu

RE: Sunshine Request – Data compilation of reported accidents for bulk milk haulers and active and new hauler licenses from Jan 1, 2007 through Jan 1, 2014.

Dear Mr. Benedict:

This will acknowledge the receipt of your April 10, 2014, which was revised on July 21, 2014 for records under the Sunshine Law, Chapter 610, Revised Statutes of Missouri. Under the Missouri Sunshine Law, all open records maintained by the Missouri Department of Agriculture will be made available to you.

The Department is reviewing your request for records that are responsive to your request.

You should expect to hear from the Department on or before August 30, 2014.

Sincerely,

Christy Moody
Executive Assistant to the Director
(573) 522-1533

APPENDIX B
NOT HUMAN SUBJECTS APPROVAL LETTER

9/17/2014

William Benedict

whb87970@ucmo.edu

Dear William Benedict,

Your research project, 'Master's Thesis', was determined to be 'not human subjects' by the Human Subjects Review Committee on 9/16/2014.

Please note that you are required to notify the committee in writing of any changes in your research project and that you may not implement changes without prior approval of the committee. You must also notify the committee in writing of any change in the nature or the status of the risks of participating in this research project.

Should any adverse events occur in the course of your research (such as harm to a research participant), you must notify the committee in writing immediately. In the case of any adverse event, you are required to stop the research immediately unless stopping the research would cause more harm to the participants than continuing with it.

If you have any questions, please feel free to contact me.

Sincerely,

Janice Putnam Ph.D., RN
Research Compliance Officer
putnam@ucmo.edu

cc: Dr. Ronald Woolsey