

An analysis of crashes involving farm equipment as reported in the Kansas Department of
Transportation database from the years 2015-2024

by

Madison Sultz

B.S., Kansas State University, 2024

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Agricultural Education and Communication
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2026

Approved by:

Major Professor
Dr. Jonathan Ulmer

Copyright

© Madison Sultz 2026.

Abstract

This study aims to analyze crash data involving farm equipment in Kansas from 2015-2024 to identify the common types of crashes and where they occur. By understanding these patterns, we can further investigate the underlying causes of these incidents. Kansas Department of Transportation crash reports were reviewed for crashes involving farm equipment in Kansas from 2015 to 2024. Key data points included the date, time, type of incident, weather, and lighting conditions. For each report, the incident narrative, age of drivers, and types of vehicles were also used. These factors were analyzed to gain insights into the nature of each incident. From 2015 to 2024, 1,032 reported crashes involving farm equipment occurred. Many of these crashes happened in the afternoon in daylight, on blacktop roadways, with no adverse conditions. The incidents that occurred most frequently were rear-end collisions ($n = 200$, 19.4%), left-hand turns ($n = 176$, 17%), collisions with fixed objects ($n = 149$, 14.4%), and sideswipes ($n = 122$, 11.9%). Of the 732 crashes that occurred between farm equipment and passenger vehicles, 507 (69%) resulted in more damage, injury, or fatality in the passenger vehicle than the farm equipment. Further research is needed to understand the contributing factors of crashes involving farm equipment. Limitations of this analysis are the underreporting of crashes, particularly those occurring on private property or those with minimal damage and reporting officers with limited knowledge of farm equipment terms. A continuation of this study will focus on high-crash areas to develop targeted mitigation strategies.

Table of Contents

List of Figures	vi
List of Tables	vii
Acknowledgements	viii
Chapter 1 - Introduction.....	1
Background and Setting.....	1
Significance of the Study	2
Purpose and Objectives.....	5
Limitations	5
Definitions	6
Chapter 2 - Literature Review.....	7
Introduction.....	7
Injuries In Agriculture	7
Types of Collisions	8
Opinions on Roadway Safety from Farmers.....	9
Conditions During Collisions	10
Alcohol and Farm Equipment.....	11
Lighting and Marking	12
Youth and Adolescents on Farm Equipment	14
Conclusion	16
Chapter 3 - Methodology	17
Introduction.....	17
Research Design	17
Population and Sample	18
Data Collection	18
Data Analysis	20
Chapter 4 - Results and Analysis	22
Introduction.....	22
Research Objective One.....	22
Research Objective Two	25

Research Objective Three	27
Research Objective Four	32
Chapter 5 - Discussion and Conclusion	34
Introduction.....	34
Discussion and Conclusion	34
Recommendations.....	37
Practical Implementation	37
Future Research	39
References	40

List of Figures

Figure 4.1 Box plot for age of drivers with blue representing equipment operators and orange representing the other drivers.....	25
Figure 4.2 ArcGIS map of all crashes involving farm equipment.....	33

List of Tables

Table 4.1 Most Common Types of Incidents Involving Farm Equipment	23
Table 4.2 Farm Equipment Crashes by Month	26
Table 4.3 Rear End Crashes for the Past 10 Years	27
Table 4.4 Left Turn Crashes in the Past 10 Years	28
Table 4.5 Fixed Object Crashes over the Past 10 Years	29
Table 4.6 Sideswipe Crashes in the Past 10 Years	29
Table 4.7 Intersection Crashes in the Past 10 Years	30

Acknowledgements

Kansas Department of Transportation (KDOT) provided crash reports for this study.

All Reporting Law Enforcement Officers for write reports to the best of their ability.

K-State Extension (KSE)- Tawnie Larson provided the space for this work to be conducted with Taylor Schroeder doing initial analysis work for her.

My committee- Thank you Dr. Ulmer for your guidance and support, Dr. Brokesh, for your expertise and guidance, and Dr. Hock for your attention to detail and support.

Chapter 1 - Introduction

Beginning in the fall of 2024, faculty, staff, and students had the idea to take the information they already had and analyze it more deeply. This led to a complete analysis of crash reports that involved farm equipment from the Kansas Department of Transportation (KDOT). This could also pave the road for more research to be done in Kansas on roadway safety for farm equipment and the driving public. This study focuses on analyzing crash reports that involve farm equipment in the past ten years. The problem arose when discussing with other state agriculture safety teams, when they stated that they were monitoring the crashes that involve farm equipment in their states. We took that information and used it to contact KDOT and request ten years of crash data with at least one vehicle in the report labeled as farm equipment.

Background and Setting

The American Society of Agricultural and Biological Engineers (ASABE) defines agricultural field equipment as tractors, self-propelled machines, implements (both towed or self-propelled), and combinations of these, designed for farming and forestry. These pieces of equipment will be referred to as “farm equipment” throughout this study. Crashes between farm equipment and the general driving public are not a common occurrence and generally are not as well studied as other roadway crashes (Karimi & Faghri, 2021). The lack of study is partially due to the way they are reported by law enforcement. Many officers are not familiar with farm equipment and therefore have trouble describing the equipment and capturing the nuances of a crash. Machine age, type, model, and other details of agricultural equipment are not easily understood by individuals who are not in the agriculture industry (Successful Farming, 2025). Further, the equipment is specialized and may only be used during certain parts of the year, which can impact general knowledge. Law enforcement officers are not the only ones with a lack

of understanding of farm equipment. According to Costello et al. (2003), there has been a demographic shift resulting in a smaller percentage of population involved in agriculture. This means that there are fewer drivers with backgrounds in agriculture, and therefore a lack of knowledge of how to interact with farm equipment on the roadway.

Significance of the Study

Equipment drivers in areas with an increasing rural population reported that there was a lack of respect towards them on the roadway using examples of aggressive driving and unsafe passing (Costello et al., 2003). The public are not the only problem; farm operations are also adjusting to new populations where once quiet roads are now busy with added traffic (Luginbuhl et al. 2003). While crashes with farm equipment are not as common, when they do occur, they have a higher likelihood of being severe (Greenan et al., 2014). Most crashes involve a passenger vehicle of some type which almost always has more severe damage than the farm equipment (Costello et al., 2009). The nature of farm equipment is part of this. Farm equipment is heavier built, and larger than most passenger vehicles on the road. Another reason is due to the high-speed differential between farm equipment and other vehicles on the roadway. Characteristics of roadway crashes involving farm equipment seem to be consistent across the United States. These crashes often occur during daylight hours, the highest percentage of crashes happening between the hours of 12:00 h and 18:00 h (Costello et al., 2003). While later in the year, 18:00 h can be the start of sunset; crashes are most prevalent between May and October (Franklin et al., 2019). Larger operations with large geographic area were found to be at higher risk for crashes along with non-English speaking operators, young (under 16) equipment operators, understaffed operations, and non-family hired help (Costello et al., 2009). For producers, driving farm equipment on a roadway is an everyday task, but it is not always a safe task. While other states

have not focused on these safety concerns, North Carolina went straight to the equipment operators. North Carolina public roads that were once sparsely traveled are now increasing in use, causing competition between drivers. Drivers in North Carolina are becoming increasingly worried about their safety on rural roadways (Luginbuhl et al., 2003). Factors like increased road traffic, speeding, unprotected intersections, illegal passing, lack of shoulders, and a lack of understanding of equipment by other drivers could be part of the problem (Costello et al., 2003). Attempting to avoid a crash with another vehicle could put the farm equipment operator at risk of a rollover or hitting a fixed object.

Farm equipment has lighting and marking requirements to improve visibility and notify other drivers of speed and size differentials. One hundred fifty-three farm tractors from four rural Kentucky counties were evaluated on their safety. Slow Moving Vehicle emblems (SMVs) were missing from 53.64% and were correctly placed and in the proper condition on 25.83% of the tractors (Cole et al., 2009). This could be a contributing factor to rear-end crashes. Only 40.94% of the sample had properly mounted, fully functional head and taillights, 24.16% with no functional lights, 19.87% had properly cleaned, mounted, and functional rearview mirrors, and 69.54% had no rearview mirrors (Cole et al., 2009). This could be a contributing factor to left-turn crashes, as well as crashes that happen in the dark. The driving public have been exposed to the SMV emblem for over 40 years; however, only 30% of the randomized driving public could correctly identify the SMV, a troubling response rate for any warning device (Garvey, 2003).

Four years of crash data in Ohio was collected in 1995; most crashes being in the daylight hours between 12:00 h and 18:00 h and turning left was the most prominent preceding action for angle collisions (Glascock et al., 1995). According to the Kansas Drive to Zero Crash Data Dashboard, more overall crashes occur in the daylight hours of afternoon from noon to 20:00 h

than in the morning from 8:00 h to 12:00 h. A 2021 literature review was completed suggesting that in various states, most crashes involving farm equipment occurred during the daytime, under clear weather conditions, and on a dry surface. The mitigation suggestion was to improve lighting and marking, ensuring farm equipment has a Rollover Protection Structure and seatbelts, educate the public as well as farmers, and make road improvements as these are the most effective safety improvement strategies (Karimi & Faghri, 2021).

Farm equipment operators can receive traffic citations similar to the driving public. Seventy-five percent of farm equipment operators in North Carolina believe that compliance with laws such as improper passing, failure to reduce speed, failure to yield, and many others would be greater if penalties and citations were increased for non-compliance (Luginbuhl et al., 2003). The lack of respect for other drivers and increased speed on rural roads was thought to be the main risks for the same North Carolina operators; however, equipment operators who were cited were often not following safe movement laws (Luginbuhl et al., 2003). Notably, farms that have a history of reported injury are at higher risk for farm equipment to crash on the roadway, likely due to repeated behaviors such as taking shortcuts for tasks or being too comfortable with everyday tasks, causing a lack of awareness (Costello et al., 2009).

While any roadway crash can have negative impacts, a basic tractor such as a 2023 100 to 174 Horsepower tractor can cost around \$157,000 on auction sites such as Tractor House. Crashes involving farm equipment have a large impact on a farming operation due to this large price tag, as well as the challenges with renting or leasing farm equipment should theirs be destroyed or inoperable. Renting a piece of equipment by the hour, day, week, or month could be realistic for some operations but not all as shown by Dhuyvetter et al. (2010).

This study is important because according to the AAA Foundation for Traffic Safety (2023), 94.5% of U.S. residents ages 16 years and older drive at least occasionally. All roadway users, including farm equipment operators, deserve to be able to drive as safely as possible. This study will lead to future studies to determine what needs to be done to make Kansas roads safer. It is also important because while there have been regional studies about crashes involving farm equipment, a study focusing specifically on Kansas crashes, has not happened. In order to effectively analyze the entire region or United States, a small scale has to be started first.

Purpose and Objectives

Farm equipment crashes are the result of many types of roadway encounters. The purpose of this study is to identify the types of farm equipment crashes and to describe the specific types over time. The objectives of this study are as follows:

1. Identify the most common crash types.
2. Describe the most common time of year for farm equipment crashes.
3. Describe annual occurrences of each farm equipment crash type.
4. Identify geographical hotspots of farm equipment crashes.

Limitations

A limitation of crash reports involving farm equipment is that they are highly dependent on the reporting law enforcement officer, leading to inconsistencies in the reporting. Some reports are in detail, including year, make, and model of the farm equipment, and there are reports that only include that a tractor was involved. There are also varying levels of agricultural knowledge between reporting officers, leading to incorrect farm equipment being reported. Because Kansas does not have a code for construction equipment and road graders, those crashes often are included in the farm equipment category, even though they are not farm equipment.

There are also crashes that include trucks and trailers that are hauling farm equipment; however, the driver of the truck is not employed through a farm but instead by a trucking company.

Another limitation is the underreporting of crashes. Kansas State 2012 Statute 8-1604 (b) states that if no officer is present, crashes need to be reported only if there is an injury or fatality, or if there is apparent property damage of \$1,000 or more. Underreporting also occurs when incidents happen on private property.

Definitions

Responsibility- Assumptions made by the researcher who is not an expert in the field to the best of their ability with the information provided in the crash report to better analyze data for statistical purposes.

Farm equipment- Tractors, self-propelled machines, implements (both towed or self-propelled), and combinations of these, designed for farming and forestry. (ASABE)

Reporting law enforcement- Could be any member of the Kansas Highway Patrol, county Sheriff's offices, and/or local Police departments.

Crash- a vehicle colliding with an obstacle or another vehicle

Chapter 2 - Literature Review

Introduction

There are a variety of studies involving traffic safety in the United States. However, few are done surrounding farm equipment safety on the roadway, no matter how needed it is. Recent population-based studies found that virtually all farm operations require travel on public roadways (Gerberich et al., 1996). When roadway studies are done, they are often done on a regional scale. For example, a study based on seven Midwest states- Iowa, Illinois, Kansas, Nebraska, Wisconsin, and North Dakota, and South Dakota- found that Iowa had the highest rate of farm equipment crashes at a rate of 10.7 crashes per 100,000 population per year (Peek-Asa et al., 2007). One of the reason equipment on the roadway is challenging to study is many of these incidents go unreported (Gerberich et al., 1996), crash report data is often incomplete, biased, old, or nonexistent (Costello et al., 2003), and the vehicle reporting is solely based on the reporting law enforcement officer, using no coding manual with exact definitions (Peek-Asa et al., 2007). These studies seem to be consistent with the current study's viewpoint on excluding trucks, trailers, and all-terrain vehicles (Peek-Asa et al., 2007). Therefore. This study addresses frequent collision types and characteristics, farmer perspectives on roadway safety, alcohol impairment, agricultural injuries, and youth involvement.

Injuries In Agriculture

Injuries in agriculture often go unreported (Leigh et al., 2014). Agriculture has consistently ranked among the most hazardous occupations; however, injury estimates likely underrepresent risk due to the exclusion of workers under age 14 and operations with ten or fewer employees (Gerberich et al., 1996). The typical injuries associated with augers, hay balers,

tractors, power take-off units, and animal handling events are often studied. However, there have not been enough studies on on-road farm vehicle injuries and fatalities (Gerberich et al., 1996). Farm equipment crashes often involve an injury or fatality (Mehlhorn et al., 2015), likely when the point of contact was the rear or side of the vehicle (Peek-Asa et al., 2007). In order to correctly study injuries and fatalities in the agriculture industry, crashes involving farm equipment also need to be included.

Types of Collisions

Motor vehicle crashes happen every day in the United States. Death rates in motor vehicle crashes are inversely associated with population density. Crash fatality rates are almost double in rural counties than in urban counties (Peek-Asas et al., 2007). One study stated that in two vehicle crashes, farm equipment was most likely struck in the rear and a very small amount of crashes involved a left-turn (Gerberich et al., 1996), while another study stated that most crashes involved the farm equipment being hit in the rear, being hit while turning left, and head-on collisions (Luginbuhl, 2003). This could be because the most common contributing factor for farmers was automobiles failure to yield to the right-of-way, specifically during left-turns, while the most common contributing factor for the other vehicle was loss of control and speeding mostly during passing (Peek-Asas et al., 2007).

Similarly, a study based in Ohio found that the most common crash type involving farm equipment over four years is rear-end crashes, followed by sideswipes from the same or opposite direction, and angle collisions (Glascok et al., 1995). Glascok (1995) also stated that the majority of angle collisions and nearly half of the sideswipe collisions occurred when the farm equipment was turning left. From that same study, the most common vehicles involved other

than the farm equipment were cars, followed by trucks and motorcycles, with some being labeled as other or not stated (Glascock et al., 1995).

The most common timeframe for these crashes was between 12:00 h and 18:00 h. In a study comprised of six years of Texas crash data, it was found that non-county roads were more affected by lighting conditions, intersection-related factors and population group (Islam et al., 2025). Comparing intersection crashes, crashes occurring in rural intersections were found to be more likely to result in injury and fatality (Tay, 2015). Islam (2025) suggested that strategic plans be developed based on contributing factors associated with crashes involving farm equipment, using targeted education and outreach programs to address behavioral risk factors, and focus on safer intersections and safe speeds.

Opinions on Roadway Safety from Farmers

Although studies provide valuable insights into roadway safety, farmers' opinions are equally important. Roads have begun to see more traffic at higher rates of speed due to farmland shrinking and suburban housing growing (Luginbuhl, 2003). Farms are sharing once quiet roads with a growing population of non-farm vehicles (Costello et al., 2009). Commuters and drivers of faster-moving vehicles could become impatient, resulting in unsafe driving activity (Costello et al., 2009).

Prior to examining opinions, literature on roadway activity in North Carolina was reviewed. Luginbuhl (2003) mentions that typical violations for non-farm equipment included failure to reduce speed, improper passing, and driving left of center. However, Luginbuhl (2003) also says that those operating farm equipment are frequently warned for unsafe movement, particularly improper left turns onto a dirt roadway, as well as lighting and marking violations.

With that study, Luginbuhl (2003) looked at opinions of farm equipment operators on the roads, which had the opinions that there was too much traffic on the road, speeding was an issue, winding roads were an issue, and that there was a lack of respect or knowledge for farm equipment, with lack of respect and increased speed posing the greatest risk. Most traffic citations for the farm equipment operators were failure to yield, improper turn, and inattentive driving (Marlenga et al., 2006).

North Carolina farmers believed that an increase in citations would make the roads a safer place (Luginbuhl, 2003), however Marlenga (2006) stated that even though the percentage of citations were more than double, the change wasn't significant. Farms reporting a history of injury on the farm were at a larger risk of on-road crashes, indicating the overall behavior towards farm safety (Costello et al., 2009). Costello (2009) also found that smaller farms that indicated having a time constraint were also at risk due to needing to get more work done with less help than larger farms, leading to quicker actions and unintentional carelessness.

Conditions During Collisions

Assumptions could be made that crashes would be more likely to occur at night. However, most crashes involving farm equipment occurred during daylight conditions (Glascock et al., 1995; Gerberich et al., 1996; Peek-Asa et al., 2007; Karimi et al., 2021). The majority of crashes also often occur between May and October, the most active time for production agriculture in the United States (Glascock et al., 1995; Peek-Asa et al., 2007; Karimi et al., 2021; McFalls et al., 2022). Crash reports identified most crashes occurring during afternoon hours, with clear, dry weather conditions (Costello et al., 2003; Peek-Asa et al., 2007; Mehlhorn et al., 2015; Karimi et al., 2021; McFalls et al., 2022; Toussaint et al., 2017).

While fatal crashes do not occur often (Gerberich et al., 1996; Costello et al., 2003) one life lost to a lack of roadway safety is too many lives. These crashes are suspected to occur because of failure to reduce speeds, improper passing, lack of shoulders and placement of mailboxes, farmers attempting to avoid a crash which results in a rollover incident, and increased public road traffic (Costello et al., 2003), failure to obey stop signs, visual obstructions and following too closely which are all preventable factors (Peek-Asa et al., 2007). Unfortunately, most attention is focused on streets that fit within the urban model, neglecting rural roads and farm equipment as a mode of transportation (Greenan et al., 2014).

During one study, all of the high-crash-rate locations did not have farm equipment warning signs present in either direction (Mehlhorn et al., 2015). Ranapurwala (2016) found that driving behavior changes based on increased caution as well as the presence of signs or pavement reflectors before curves and large hills/mountains. This can indicate the effectiveness of road markings and signage as well as the education of consequences if driving behavior is not changed in certain scenarios. For example, Ghanbari (2023) found that only 10% of respondents considered farm equipment crashes to be a top-rated safety concern. This may reflect limited awareness of the risks associated with farm equipment crashes, including their comparatively higher fatality rates than other types of motor vehicle collisions (Karimi et al., 2021), and that males have a higher risk of being involved in these crashes due to their reported passing frequency (Ghanbari et al., 2023). Ghanbari's (2023) study emphasized the need for increasing social awareness and knowledge about how to share the road.

Alcohol and Farm Equipment

It is frequently assumed that farmers engage in heavy alcohol consumption due to the specific stressors of their occupation (Ayer, 2024). Yet empirical evidence indicates that alcohol

plays a minimal role in farm equipment-related crashes, accounting for only 3% of such incidents (Glascocock et al., 1995, Harland et al., 2018). On the other hand, farm equipment operators are often overlooked when using rural roadways as long as a crash does not occur (Harland et al., 2018). Crashes that resulted in minor damage and no injuries are less likely to be reported to police. When crashes did occur, 17.8% of fatal crashes and 5.6% of injury crashes involved an alcohol-impaired driver, either equipment operator or other driver (Harland et al., 2018). These crashes occurred mostly in rural zip codes, on Friday nights between 18:00 h and 23:59 h, in the dark, and were head-on or rear-end crash types (Harland et al., 2018). While age was evenly distributed in crashes with alcohol impairment (Harland et al., 2018), there is a need to emphasize that driving while impaired, even if driving farm equipment, can still end in crashes with injuries and fatalities, and is, overall, still against the law.

Lighting and Marking

Lighting and marking has been an important topic surrounding farm equipment roadway safety for many years. ASABE defines slow-moving vehicle (SMV) as “An animal-drawn or motorized conveyance, including implements in tow, that is designed for and travel at rates of speed less than 40km/h (25mph) (Garvey, 2003). Crashes were reduced by more than half when proper lighting and marking standards were followed (Ramirez et al., 2016). The SMV emblem has been used for over 40 years, however, it is not widely recognized, leading to its ineffectiveness (Garvey, 2003). Compliance scores from seven Midwest states showed that Illinois, Kansas, and North Dakota were the states most compliant with lighting and marking standards (Ramirez et al., 2016). When asked which signage to use, the majority of respondents preferred the traditional triangle-shaped slow-moving tractor sign, followed by the circular sign

indicating the speed limit of an automobile and a tractor, and a rectangular sign noting “speed limit” and stating 20 mph for a tractor and 55 mph for an automobile (Luginbuhl, 2003).

ASABE Standard 279 (2008) is updated frequently and provides manufacturers with a guideline for lighting and marking types, placement, colors, and performance. These requirements are specifically designed for farm equipment to be visible, recognizable, and predictable to the driving public and other roadway users (ASABE, 2008). The Agricultural and Machinery Illumination and Safety Act (AMISA) is the federal regulation, 49CFR, part 562, that provides legal authority to make the standard enforceable. AMISA states that any equipment manufactured after June 22, 2017 must meet ASABE Standard 279 (ASABE, 2016). ASABE Standard 279 (2008) and AMISA (Lighting and marking on agricultural equipment, 2016), work together to ensure that farm equipment operated on public roads are visible and protected, reducing the risk of crashes involving farm equipment. However, older unlit, unmarked farm equipment is of concern, as of 2016, no states required the retrofitting of older farm equipment to be in compliance with the lighting and marking standards set by ASABE (Ramirez et al., 2016). Additional studies and prevention efforts continue to be crucial in reducing the most common crash types and protecting everyone on roadways (Peek-Asa et al., 2007).

During 2006 in Kentucky, 64% of motor vehicle collisions occurred in urban areas, with 56% of fatal events occurring in rural counties (Cole et al., 2009). More specifically, there were 408 Kentucky highway collisions that involved farm equipment in one year, 11 of those being fatal, and 140 total injuries (Cole et al., 2009). These crashes resulted in four Kentucky county schools working to inspect farm equipment based on the National Agricultural Tractor Safety Initiative. Copies were distributed and discussed while also emphasizing recommendations for use of Rollover Protection Structures (ROPS) and seatbelts to prevent operator falls and ejections

during overturns, proper lighting and marking, starter terminal shields to prevent runovers, proper shielding of the Power take-off unit (PTO), and the proper access steps and handholds (Cole et al., 2009). This project found farm equipment that did not have proper ROPS systems, farm equipment that did not have seatbelts, and seatbelts that were not clean and retractable showing signs of unuse (Cole et al., 2009).

This project increased the students' awareness of highway safety issues related to the presence of farm equipment and other motor vehicles traveling along rural highways, particularly for students not familiar with farming and tractors. It promoted dialog about tractor safety issues with adult farmers and other community members. It provided empirical data about the safety status of a non-random but representative sample of tractors that regularly travel public highways, and it provided teachers and students with a worthwhile community service project (Cole et al., 2009).

Youth and Adolescents on Farm Equipment

Operating or riding on farm equipment is one of the leading causes of farm-related injuries and fatalities among children and adolescents (Toussaint et al., 2017). Some, but not all, areas have incorporated farm vehicle information into their driver's education handbook (Costello et al., 2003). While that can help other drivers be more aware of farm equipment, it does not impact the lack of awareness about when farm equipment is on the road and how the equipment operator and driving public should interact. In 2003, Costello et al. mentioned that no programs were identified that specifically incorporate the "share the road" communication message, however, in 2024, multiple social media posts focused on "share the road" were dispersed via Kansas Department of Transportation and Kansas Highway Patrol (Kansas Highway Patrol [KHP], 2024).

One aspect of farm equipment crashes that is often debated is the age of the operator. Studies have found no change in crashes where youth tractor operators were at fault, nor in the number of contributing circumstances attributed to the operator (Marlenga et al., 2006). However, that could be because of the tractor certification course that is required of all youth farm equipment operators. On one hand, youth participating in this course are becoming more familiar with the equipment and how to properly operate it, on the other, the course was not designed to prevent youth tractor crashes but rather to meet federal exemption requirements that allow youth to work on a farming operation (Marlenga et al., 2006). Although crashes involving youth-operated farm equipment in Kansas uncommon, studies have reported limited compliance with tractor certification requirements, particularly in contexts where enforcement has been minimal (Marlenga et al., 2006). This has led researchers to explore alternative approaches to crash prevention, such as restricting the operation of farm equipment on public roadways to licensed drivers (Peek-Asa et al., 2007).

A study was completed over nine Midwest states, focusing on child and adolescent occupants during equipment related crashes. While only 6% of crashes involved children or adolescent occupants, most of those crashes were child driver only, meaning the child was driving, and the only occupant of the farm equipment, with the least common being child driver and child passenger (Toussaint et al., 2017). It is important to emphasize that even when an adult is driving, children are still at risk for sustaining injury in a crash (Toussaint et al., 2017). Refraining from allowing children on tractors, even if it is the agriculture culture, as well as only allowing licensed drivers, provisional or fully licensed, to operate a vehicle on public roads, could save a life.

Another study focused on how the tractor safety curriculum was being taught. Researchers focused on the retention rate of information among teachers, simulating how students would retain the same information. Their pre-test scores indicated some general knowledge of tractors and machinery, but by the end of the program, teachers indicated that they wanted to continue hands-on activities that were focused on how to teach the skills relevant to secondary students which will be crucial in reducing work-related injuries caused by agricultural machinery and tractors (Pate et al., 2019).

Conclusion

Further work is required to enhance knowledge regarding farm equipment on-road use and crash incidents (Franklin et al., 2020). One area that needs specific improvement is lighting and marking as well as Rollover Protection Structures used in conjunction with seatbelts, education for the public and farmers, and road improvements for effective safety improvement strategies (Karimi et al., 2021).

All studies reviewed were conducted in regions of the United States other than Kansas. In order to effectively improve roadway safety for the entire U.S., a smaller scale is needed so the focus is on the state's specific environment and needs. An identified drawback of the reviewed studies is that many relied on self-reported measures. That leaves room for bias and inaccurate information.

Chapter 3 - Methodology

Introduction

All crashes involving farm equipment from 2015 to 2024 were analyzed. Crashes are defined as a vehicle colliding with an obstacle or another vehicle. Crash reports were requested through the KDOT open records general request form, where researchers had to certify that K.S.A 45-220(c)(1) and (2) were followed. This states that use of any names or addresses contained in the reports would not be shared as well as reports would not be made available to any person. After successfully receiving the crash reports for crashes involving farm equipment from 2015-2024, all crash reports were put into Kansas State University's secure database. Each report was read, and relevant data was entered into a spreadsheet using Microsoft Excel. This information included date of the crash, time of the crash, details of the crash, location, all drivers' age, all vehicle details, weather conditions and lighting conditions. While reading each crash report, the reports that included construction equipment, road graders, or did not include farm equipment were removed. After all data was collected in the spreadsheet and cleaned, Microsoft Excel was used to determine crash totals, crash types, average driving age, most common time of year for crashes involving farm equipment, and annual occurrences for farm equipment crashes. Statistical Package for Social Sciences (SPSS) version 30.0.0 was then used for correlations. Finally, a map was created using ArcGIS and locations to identify hotspots for farm equipment crashes.

Research Design

According to Sage Research Methods (2021), archival research is the locating, evaluating, and systematic interpretation and analysis of sources found in archives. By that definition, archival research was used to collect crash reports from the KDOT archives, evaluate

those crash reports, and interpret and analyze the results. The design type for this study is a combination of Geographical and Temporal Analysis, defined by Yin (2016) as “ A process that allows to characterize subsets of items in a geographic database, for example events, with respect to the similarity of their location and timestamp,” due to mapping and identifying hotspots, as well as reviewing the historical trends and time-of-day patterns. Those design types were also in combination with Collision Diagramming (Litvin et al.), which was used to visualize specific crash types, severity, and determine contributing factors at intersections. This study is also quantitative research with future research opportunities for a qualitative study.

Population and Sample

The population size was the total number of reports sent by KDOT which was 1,143 reports. Those crash reports included crashes that were excluded from the sample. Kansas crash reports do not have a category for construction equipment. This caused 111 reports to be removed from the sample. Construction equipment included skid steers, road graders, and various other construction equipment where the report made clear the equipment was owned by a construction company or the city, making it clear the equipment was not used as farm equipment. Four crashes were separated from the main statistics due to being a farm equipment on farm equipment crash that were not accounted for in the original research plan; these were analyzed separately, resulting in a sample size of 1032 crash reports from 2015-2024.

Data Collection

All crash reports in Kansas are reported on KDOT Form 850A; these are the reports that were received upon request. All crash reports that had a vehicle marked as “08-farm equipment” were read and reported in an Excel spreadsheet. The 08-farm equipment code is significant due

to the focus of this study being crashes involving farm equipment. That spreadsheet contained details from the report such as date, time, weather conditions, lighting conditions, types of vehicles, road type- as determined by KDOT, road material, ages of drivers, ages of vehicles, the owners of the vehicles involved in the crash, if the drivers were appropriately licensed, if the drivers were under the influence, and if the crash was a hit and run. Each report also included a narrative and a drawing of the crash scene, which allowed researchers to determine the type of crash. Reports of any injuries or fatalities were also included.

Microsoft Excel was used to separate data into categories so that researchers could study incident type, road type, lighting conditions, and weather conditions in greater depth. Incident type included rear-ends, left-turns, fixed objects, sideswipes, intersections, other, rollover, parked vehicle, fire, right-turn, exiting a private driveway, vehicle malfunction, collision with a train, reversing, debris, and head-on. The incident type was determined to the best of the researcher's ability based on the information written in the crash report narrative, which is completed by the reporting law enforcement officer. Road types were 01-concrete, 02-blacktop, 03-gravel, 04-dirt, 05-brick, or 88-other. Road type was determined and reported by the reporting law enforcement officer and was indicated on the crash report. Lighting conditions included 01-daylight, 02-dawn, 03-dusk, 04-dark: streetlights on, and 05-dark: no streetlights on. These conditions were determined and indicated on the crash report by the reporting law enforcement officer. Weather conditions included: 00-no adverse conditions, 01-rain, mist, and drizzle, 02-sleet, hail, 03-snow, 04-fog, 05-smoke, 06-strong winds, 07-blowing dust, sand, etc., 08-freezing rain, 14-rain and fog, 15-rain and wind, 24-sleet and fog, and 36-snow and wind. Weather conditions were also determined and indicated on the crash report by the reporting law enforcement officer. All collected data was put into an Excel spreadsheet for analysis.

Data Analysis

All reports were successfully obtained following the request. Each crash report was read to organize all data in a Microsoft Excel file. Statistical Package for Social Sciences (SPSS) version 30.0.0 and Microsoft Excel were used to organize and analyze all data. ArcGIS was used to create a map, which was used to identify hotspots.

During that time, any crash reports that were mismarked as farm equipment, reports that did not include farm equipment, any reports that reported road graders or construction equipment as farm equipment, and any semi-trucks that were not directly stated as hauling grain or owned by a farm were excluded. Crashes involving two pieces of farm equipment were isolated and analyzed separately because the crashes were different in nature.

SPSS Version 30.0.0 was used to determine correlations between crashes and variable factors present. A correlation analysis was used due to needing to determine how the independent, categorical variable (equipment type and road material) and the dependent, ordinal variable (road material). With the negligible correlations, it was determined that both equipment type and crash severity as well as road material and severity are not related.

There was potential bias when excluding data, due to how the definition of farm equipment changes from person to person. That bias was limited due to using the definition from ASABE and using the inclusion and exclusion criteria previously defined. Another potential bias was when assigning responsibility to intersection crashes. While Kansas is a no-fault state, the research team used the narrative for each crash, such as someone running a stop sign or rear ending another vehicle, to assign responsibility for the purpose of this study.

Some limitations to this study include the reporting officer not having previous knowledge of farm equipment to properly identify the official names of equipment and

implements. This made the study challenging because the types of implements that were most common in these crashes could not be analyzed. Another limitation was the variation between each crash report. Some reports were detailed in a way that was easily analyzed while some reports had the bare minimum information, specifically in the narrative and sketch of the scene sections.

Chapter 4 - Results and Analysis

Introduction

In this study, objective one focuses on identifying common types of farm equipment crashes in Kansas from 2015-2024. This was done through the collection of crash reports from the Kansas Department of Transportation (KDOT). Crash types and characteristics were recorded and analyzed using Microsoft Excel. That leads to objective two, which is to describe the most common time of year for farm equipment crashes. This was done using the dates that were recorded from the crash report. Objective three was completed by describing annual occurrences of each farm equipment crash type using the narrative of each crash report. Finally, objective four was completed by identifying geographical hot spots of farm equipment crashes using a map generated using ArcGIS and the longitude and latitude points given by KDOT.

Research Objective One

Research objective one focuses on identifying the most common types of farm equipment crashes in Kansas from 2015-2024. In total, 1,032 crashes involving farm equipment have occurred in high-traffic areas in the past 10 years. These crashes often occur in high traffic areas and areas with increasing populations. Roadways with no shoulders have a high occurrence of crashes involving farm equipment due to it being a challenge for equipment to allow enough room for other drivers to pass safely, as well as obstacles such as signs being on the side of the road, not allowing room for equipment to get over.

Most crashes happen during daylight (82.6%), non-adverse conditions (93.9%) with 2.1% occurring in rain, mist, and drizzle. Afternoon hours (12:00 h – 16:59 h) were the most common times for crashes involving farm equipment at 41.8%. This is consistent with all crashes in Kansas according to the Kansas Drive to Zero Dashboard. The majority (30.9%) of crashes

happened in the morning hours (5:00 h- 11:59 h), 18.9% of crashes happened in the evening hours (17:00 h – 19:59 h), 8.1% happened in the nighttime hours (20:00 h – 4:59 h), and 0.3% occurred at an unknown time. The three most common roadways where crashes occurred were labeled as “Road” (42.5%), “Highway” (27.4%), and “Street” (17.5%). KDOT defines highway as having a function for high-speed, long-distance travel, street as low-speed local travel, and road as moderate to low-speed travel with local access. Blacktop roads, also known as asphalt pavement, are semi-permanent surfaces where 57.3% of crashes occurred. Defined as a surface layer of rock over a compacted subgrade, gravel roadways were the road type for 20.8% of crashes involving farm equipment. There was a negligible correlation between equipment type and crash severity ($r = -.026$). There was also a negligible correlation between severity and road material ($r = -.014$).

The most common crashes involving farm equipment over the past 10 years (See Table 4.1) were rear-end crashes (200), left-turn crashes (175), crashes with fixed objects (148), and sideswipes both oncoming and in the same direction (122). All other crash types occurred less than 100 times. Overall, crashes involving farm equipment have been rising in total since 2021. However, 70.7% (730) of crashes resulted in damage only. More severe or equal damage was done to the passenger vehicle 65% (679) of the time. Injury was the result of 26.5% (273) of crashes, while fatalities were less frequent at 2.8% (29) of crashes.

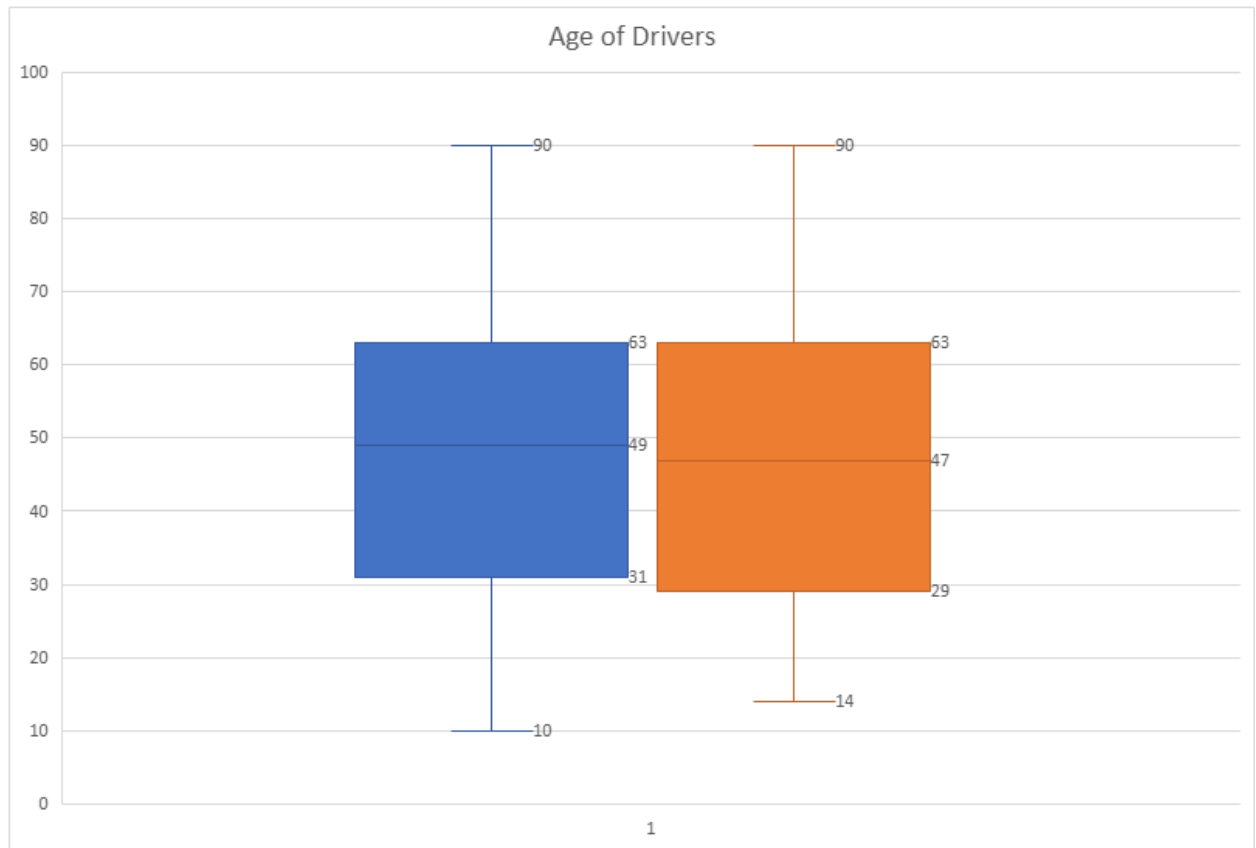
Table 4.1 Most Common Types of Incidents Involving Farm Equipment

Type of Crash	N	%
Rear End	201	19.50%
Left Turn	176	17.00%

Fixed Object	153	14.80%
Sideswipe	134	13.00%
Intersection	92	8.90%
Rollover	61	5.90%
Parked Vehicle	44	4.30%
Fire	34	3.30%
Other	34	3.30%
Exiting Private Driveway	28	2.70%
Vehicle Malfunction	25	2.40%
Reversing	21	2.00%
Head-On	9	0.09%
Right Turn	8	0.08%
Train	7	0.07%
Debris	6	0.06%

Age was also a factor that was taken into account (See Figure 4.1). The minimum age for the equipment operator was 10 years of age with the maximum being 90 years of age. The minimum age for the driver of the other vehicle involved in the crash was 14 years of age with the maximum age also being 90 years of age. However, the median age for both equipment operator and other driver were similar with equipment operator median age being 49 years of age and the other driver having a median age of 47 years of age.

Figure 4.1 Box plot for age of drivers with blue representing equipment operators and orange representing the other drivers.



Research Objective Two

Research objective two focuses on describing the most common time of year for farm equipment crashes in Kansas (See Table 4.2). The most common months for crashes involving farm equipment are June and July, followed by October; the lowest month is February. Overall crashes involving farm equipment in Kansas have been rising in total since 2021. However, that is not consistent when separated by crash type in objective three.

Table 4.2 Farm Equipment Crashes by Month

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	$\bar{x}$	sd
January	2	3	2	3	6	3	8	9	7	3	4.6	2.63
February	2	4	3	1	3	2	3	4	3	5	3.0	1.15
March	5	6	8	3	7	4	8	6	7	7	6.1	1.66
April	6	3	11	6	5	14	7	2	6	8	6.8	3.55
May	5	6	7	12	4	9	2	8	11	11	7.5	3.30
June	16	19	18	17	15	7	15	18	14	14	15.3	3.40
July	18	14	17	15	19	16	19	11	6	15	15.0	4.00
August	11	10	7	9	12	8	12	14	12	14	10.9	2.38
September	14	14	10	15	7	8	6	7	7	14	10.2	3.65
October	13	11	8	6	17	8	8	15	17	14	11.7	4.06
November	6	7	12	12	11	6	7	3	10	5	7.9	3.14
December	3	2	7	3	5	2	6	4	4	2	3.8	1.75

Research Objective Three

Research objective three describes annual occurrences of each crash type involving farm equipment in Kansas. As stated in research objective two, it was found that the total amount of farm equipment crashes in Kansas has been rising since 2021. However, when separated by crash type, the results were not consistent.

Rear-end crashes totaled 200 in a 10-year span (See Table 4.3). Damage was the most common occurrence with 101 (50.3%) crashes; 92 (46.2%) in injuries, and 7 (3.5%) in fatality. Rear-end crashes were most common in 2017 and 2022, the lowest years being 2016 and 2023 and a slight rise in 2024.

Table 4.3 Rear End Crashes for the Past 10 Years

	Amount of Crashes	Percent of Total Crashes for the Year
2015	23	23.0%
2016	13	13.0%
2017	29	26.0%
2018	15	14.7%
2019	23	20.7%
2020	18	20.7%
2021	18	17.8%
2022	28	27.7%
2023	13	12.5%
2024	20	17.9%

Left-hand turn crashes typically happen when a vehicle is passing a slow-moving vehicle on the left while the slow-moving vehicle is trying to turn in that direction. Left-hand turn crashes totaled 176 in a 10-year span (See Table 4.4). Crashes that resulted in damage only totaled 148 (84%) and 28 (16%) injuries. These crashes were most common in 2016 before trending downward until spikes occurred in 2020 and 2024, with 2023 having the lowest amount of left-hand turn crashes.

Table 4.4 Left Turn Crashes in the Past 10 Years

	Amount of Crashes	Percent of Total Crashes for the year
2015	24	23.80%
2016	25	25.30%
2017	18	16.40%
2018	15	14.70%
2019	15	13.50%
2020	17	19.50%
2021	19	18.80%
2022	13	12.90%
2023	10	9.62%
2024	23	20.50%

Crashes involving fixed objects totaled 153 in a 10-year span (See Table 4.5). Fixed object crashes resulted in 92.7% (142) being damage only, 0.7% (1) ended in fatality, and 6.6% (10) crashes ended in injury. Power poles were the object in 55% of the fixed object crashes. Of those incidents, 48% involve contact with hanging wires. Bridges were the fixed object in 16%

of fixed object crashes, where 70% of those crashes did not have a report on the damage to the bridge, 26% of bridges had extensive damage, and 4% had no damage. Also included in the data are incidents where the farm equipment fell through or off the bridge. Hit-and-run citations were common in fixed object crashes, 31% of hit-and-run crashes were fixed object crashes.

Table 4.5 Fixed Object Crashes over the Past 10 Years

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	$\bar{x}$	sd
Bridge	5	3	3	3	1	3	4	1	2	3	2.8	1.23
Power Poles	7	9	7	5	12	4	8	6	8	11	7.7	1.50
Roadway	1	3	1	3	1	1	1	0	2	1	1.4	0.97
Other	1	5	1	7	4	3	2	7	3	2	3.5	2.22

Sideswipes totaled 133 crashes (See Table 4.6). Sideswipes are defined as two vehicles crashing while passing each other, either in opposite directions or in the same direction. Crashes ended in damage only 76.7% (102) of the time, 20.3% (27) ended in injury, and 3% (4) ended in fatality.

Table 4.6 Sideswipe Crashes in the Past 10 Years

	Amount of Crashes	Percent of Total Crashes for the year
--	-------------------	---------------------------------------

2015	6	5.94%
2016	13	13.13%
2017	10	9.09%
2018	15	14.70%
2019	18	16.20%
2020	15	17.20%
2021	10	9.90%
2022	11	10.89%
2023	21	20.19%
2024	15	13.39%

There were 92 intersection crashes from 2015 to 2024 (See Table 4.7). An intersection crash is defined as a crash that occurs at the junction of two roads. These crashes do not include crashes where a vehicle was turning left, and another vehicle was attempting to pass. Damage was the result of 59.3% (54) intersection crashes, 36.3% (34) of crashes ended in injury, and 4.4% (4) of crashes ended in fatality.

Table 4.7 Intersection Crashes in the Past 10 Years

	Amount of Crashes	Percentage of Total Crashes for the Year
2015	13	12.90%
2016	7	7.07%
2017	13	11.82%

2018	8	7.84%
2019	2	1.80%
2020	9	10.34%
2021	11	10.89%
2022	6	5.94%
2023	15	14.42%
2024	8	7.14%

The narrative of each report was reviewed, and responsibility for the crash was assigned by the researcher's interpretation of the cause of the crash. The researcher, however, is not a traffic safety professional and did the best interpretation possible with the information given. For example, if an equipment operator ran a stop sign, we interpreted the crash as the responsibility of the equipment operator. On the other hand, if a passenger vehicle was passing in a no-passing zone and there was proof that the equipment operator was properly using their turn signal, the responsibility lies with the driver of the passenger vehicle. There are also times when there is equal responsibility for the crash, such as times like those previously mentioned, but the equipment operator was not properly using a turn signal, and the crash occurred in a passing zone. Researchers found that 42.5% of the time, the crash was the responsibility of the other driver, 41.4% of the time it was the responsibility of the equipment operator, and 16.1% of the time the crash was equal responsibility between drivers.

The four crash reports that were excluded due to being farm equipment on farm equipment crashes, were analyzed separately. All four crashes occurred in daylight hours with no adverse conditions. Half of the crashes happened in the morning with the other half happening in

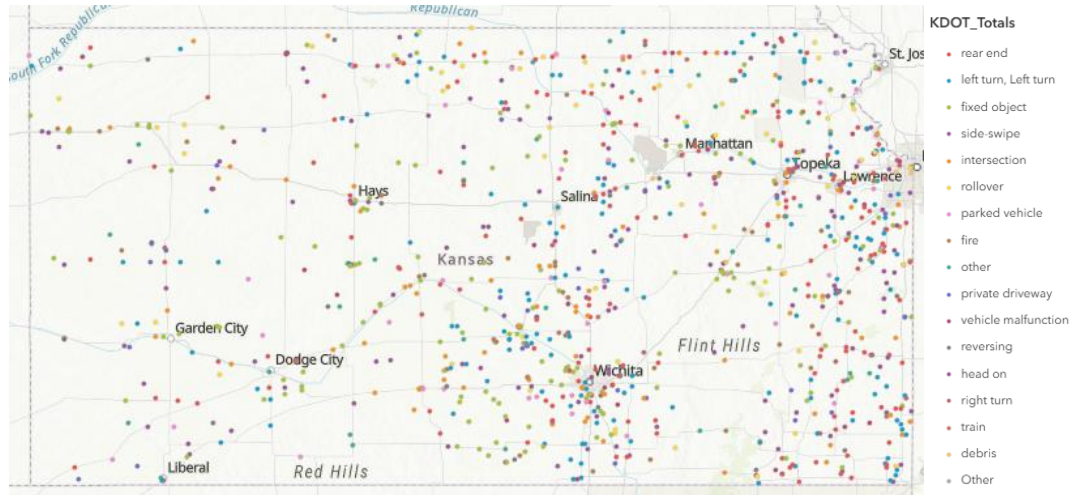
the afternoon. Two crashes were rear-end crashes, one was a left-turn crash, and one was an intersection crash. Two of the reports clearly stated that the two vehicles were from the same company. The crashes occurred between sprayers, grain trucks, combines, with one crash being grain truck versus tractor.

Research Objective Four

The final research objective was to determine where hot spots occurred for crashes involving farm equipment. For this map to be created, all crash longitude and latitude points that were provided by KDOT were entered into ArcGIS along with the crash type. After communicating with traffic safety professionals U.S. Highway 36, Kansas Highway 96, U.S. Highway 56, and Kansas Highway 9 were of most concern. These corridors were flagged as a concern due to a high crash rate overall according to traffic safety professionals. This was executed by determining the relationship between miles and number of crashes. U.S. Highway 36 resulted in 11.5 miles per crash, U.S. Highway 56 resulted in 16 miles per crash, Kansas Highway 96 resulted in 14.28 miles per crash, and finally Kansas Highway 9 resulted in 7 miles per crash.

With the four excluded crash reports being included on the map, hotspot areas were identified as areas surrounding town centers with large populations such as Wichita in south-central Kansas and Topeka and Lawrence in north-east Kansas. U.S. Highway 36, the northern most highway that runs east and west, was identified due to the consistent crashes involving farm equipment and the clear outline of the highway on the map. U.S. Highway 56 was also highlighted running in the northeast and southwest directions from central Kansas to southwest Kansas. This highway was highlighted due to the clear outline of the highway with crashes involving farm equipment.

Figure 4.2 ArcGIS map of all crashes involving farm equipment



Chapter 5 - Discussion and Conclusion

Introduction

This study's objectives were to identify common types of crashes involving farm equipment, describe the most common time of year for farm equipment crashes, describe annual occurrences of each cause of farm equipment crashes, and identify geographical hot spots of farm equipment crashes. In undertaking this study, it was hypothesized that left-hand turn crashes would be found to be the most common and most severe. However, the results indicated that rear-end crashes are more common and are more likely to result in injury than left-turn crashes. The study did not suggest possible reasons for this finding. In conversations with traffic professionals, distracted driving has been mentioned as an increasingly common problem in recent years. Distracted driving and driving under the influence, conditions that could be causes of rear-end crashes, were considered to be outside the scope of this study. The study results also seemed to indicate that more damage is done to vehicles involved in left-turn crashes than rear-end crashes. This finding seems counter to previous findings that rear-end crashes are more likely to be severe (Costello et al., 2003).

Discussion and Conclusion

A surprising finding was the number of hit-and-run crashes involving farm equipment that were found. These crashes often happen when farm equipment comes in contact with a power pole and cause damage to the pole (77). Home owners report power outages, initiating a response from utility company repair crews, who report the damage to authorities when it is discovered. The resulting crash report lists the incident as a hit-and-run crash. Some of these

incidents occur on private property. Some crashes occurred on private property; however, such incidents were included in the crash dataset only when they were reported to law enforcement.

While not common, collisions between two pieces of farm equipment do occur. In fact, from 2015-2024 there were only 4 in Kansas. When these collisions do occur, it is often between two pieces of equipment from the same farm. This could be caused by a multitude of reasons, such as distracted driving, dusty road conditions, limited line of sight, vehicle malfunctions, rushing to get work done and much more. Practicing defensive driving habits could help mitigate these scenarios.

Meeting research objective one, it was found that in Kansas, the top five crash types are: rear-end (201), left-turn (176), fixed object (153), sideswipe (134), and intersection (92). This differs from other studies where left-turn crashes were the most common crash type (Peek-Asa et al., 2007). Rear-end crashes being the most common was surprising because the agriculture safety teams across the country are more informed about the left-hand turn crashes, therefore leading us to hypothesize that left-hand turn crashes would be most common in Kansas.

Meeting research objective two, it was found that a majority of crashes involving farm equipment in Kansas occur during the months of June, July, and October. We can hypothesize that the trend is due to wheat and hay harvest, meaning more farm equipment on the roadway than in other months. This differs from other studies where fall months were highest for crashes involving farm equipment, with summer and spring being lower, and winter being lowest (Peek-Asa et al., 2007). However, in a self-reported study in nine midwestern states, the most severe crashes were reported in June-August or September-December (McFalls et al., 2021), while the study done in Kansas, pointed to June, July, and October resulting in the highest amount of crashes.

Research objective three was completed by analyzing the top five crash types involving farm equipment in Kansas by year from 2015-2024. However, there were no consistent trends between years. While this study did not point to any indications of untrained operators, a way to improve safety on roadways is to improve operator training. This was noted in an article in the *Journal of Agromedicine* that was done in 2019 (Franklin et al., 2019). Lastly, everyone could improve the usefulness of SMVs by not installing them on vehicles that travel above the 25-mph limit, as well as on stationary objects (Garvey, 2003).

Research objective four focuses on mapping the hotspots based on a visual map that was created using ArcGIS and longitude and latitude points provided by KDOT. Hotspot areas seem to be close to city centers in the central and eastern part of the state. The relation to city centers is consistent with studies done across the Midwest (Greenan et al., 2014). That could be due to more agriculture productions in western Kansas, resulting in familiarity between the driving public and farm equipment on the roadway.

Understanding youth involvement in farm equipment operation is particularly important given their role as the future agricultural workforce. Kansas State Extension currently uses the National Safe Tractor and Machinery Operation Program (NSTMOP) that was developed through Penn State University, Ohio State University, and the agricultural division of the National Safety Council. All extension agents are encouraged to offer the program to their county/district in order to train all 14- and 15-year-old youth that plan to work on farming operations (Youth Safety). Early exposure to farm equipment operation, when paired with appropriate training and safety practices, has the potential to reduce the risk of injury not only during youth but across the lifespan of agricultural work. Developing correct occupational habits and safety awareness as 14- and 15-year-olds may contribute to safer behaviors in adulthood,

reducing the long-term risk of farm equipment-related injuries. Research addressing youth training, regulation, and roadway exposure has implications that extend beyond immediate crash mitigation and into the future safety of the agricultural workforce and other driving public.

Recommendations

Practical Implementation

Based on this study, some best management practices that equipment operators and owners could implement to reduce crashes are to better obey traffic laws. Simple actions such as stopping at stop signs, yielding where appropriate, practicing defensive driving, and not driving under the influence could have reduced the number of studied crashes. Educating equipment operators on the importance of reporting all incidents, specifically those involving power poles, could reduce the number of hit-and-run crashes involving farm equipment in Kansas. Reporting any connection with power poles can minimize time spent without power for others as well as reduce citations for hit-and-runs. Other actions, such as maintaining the lighting and marking components that modern farm equipment is equipped with following 49CFR par 562 (AMISA), could potentially reduce roadway crashes as well. Also, improved training for new farm equipment operators, including new employees as well as youth, before they are allowed to operate equipment on roadways, would be helpful, as moving large pieces of equipment on a public road is vastly different than operating a passenger vehicle.

Communication needs to be better with all drivers. Given the study, we hypothesize that educating the driving public on how to interact with farm equipment when they encounter it on a

roadway could be helpful. For example, messaging that large equipment may need to enter the opposite lane to complete a wide turn is frequently misinterpreted by the driving public as an opportunity to pass. Self-reported passing behaviors suggested the need for increasing social awareness about how to safely share the road with farm equipment (Ghanbari et al., 2023). Public service announcements during peak agricultural periods to inform drivers of the heightened likelihood of encountering farm equipment on roadways could improve awareness.

While this study did not show a correlation between the age of equipment and crash type, older equipment should be modernized to meet the current ASABE lighting and marking standard S279 since equipment manufactured after 2017 is already equipped with lighting and marking that is compliant with the standard. Doing so improves visibility to other drivers, resulting in safer equipment operation on the roadway. While no state laws mandate the retrofitting of older equipment (Ramirez et al., 2016), operators can improve their safety by modernizing older equipment, particularly given that rear-end crashes are the most common crash type.

One important aspect of this study was extracting crash reports that did not involve farm equipment but had vehicles marked as such. This misclassification most often occurred in crashes involving construction equipment, as construction equipment does not have a dedicated coding option on the KDOT Form 850A. As a result, construction equipment was frequently coded as farm equipment. The KDOT Form 850A could improve by adding a specific construction equipment coding option. This addition would be reasonable given that the previously mentioned AMISA law does not apply to construction equipment. Furthermore, crashes that occur in construction zones are treated differently due to their unique characteristics, which further supports the need for a separate construction equipment code.

The hotspots identified in this study should have more signage warning the driving public about farm equipment on the roadway during peak months such as June, July, and October. However, all reporting law enforcement officers should be trained on how to properly provide a detailed report when a crash involves farm equipment. These details could include photographs, year, make, and model of the equipment, location, and detailed narrative of the incident including all lighting and marking errors. Noting these details could make research data more clear, helping to mitigate crashes involving farm equipment in the future.

Future Research

A qualitative research study is needed to occur in the near future. This study will focus more on the physical crash characteristics by utilizing technology and visiting crash sites. This will give safety teams better understanding of the root cause of each crash. Some root causes could include needing to upgrade roads to increase visibility or allow room for wide vehicles to pass other vehicles safely, distracted driving, reduced visibility to field access point along with many others. Interviews with those involved in farm equipment crashes could give better insight into the crash and the process of the crash. These details could improve how research teams give recommendations in the future.

While this study determined where and what crashes were occurring, there is a long way to go with qualitative research for roads to be safely suitable for farm equipment on the roadways.

References

- American Society of Agricultural and Biological Engineers. (2008). *Lighting and marking of agricultural equipment on highways* (ANSI/ASAE S279.14). <https://elibrary.asabe.org>
- American Society of Agricultural and Biological Engineers Technical Information Library. (2025). Asabe.org. <https://elibrary.asabe.org/pdfviewer.aspx?GUID=9C80E310-577D-4BDC-85B1-2F88ED54EDC2>
- Ayer, B. (2024, July 16). *Farming under the influence?* College of Public Health UGA. <https://publichealth.uga.edu/farming-under-the-influence/>
- Cole, H. P., Piercy, L. R., Heinz, K. L., Westneat, S. C., Arrowsmith, H. E., & Raymond, K. M. (2009). Safety status of farm tractors that operate on public highways in four rural Kentucky counties. *Journal of Agricultural Safety and Health*, 15(3), 207–223. <https://doi.org/10.13031/2013.27406>
- Costello, T. M., Schulman, M. D., & Luginbuhl, R. C. (2003). Understanding the public health impacts of farm vehicle public road crashes in North Carolina. *Journal of Agricultural Safety and Health*, 9(1), 19–32. <https://doi.org/10.13031/2013.12347>
- Costello, T. M., Schulman, M. D., & Mitchell, R. E. (2009). Risk factors for a farm vehicle public road crash. *Accident Analysis & Prevention*, 41(1), 42–47. <https://doi.org/10.1016/j.aap.2008.08.029>
- Costello TM, Wogalter MS Driver attitudes, beliefs and reported behavior associated with sharing public roads with farm vehicles. *Proceedings of the Human Factors and*

Ergonomics Society Annual Meeting, SAGE Publications Sage CA, Los Angeles, CA; 2003. p.1039–1043.

Dhuyvetter, K., Williams, J., & Dumler, T. (2010, October 1). *Leasing vs. Buying Farm Machinery -- MF-2953* | *AgManager.info*. Agmanager.info; Kansas State University.
<https://agmanager.info/leasing-vs-buying-farm-machinery-mf-2953>

Foundation for Traffic Safety. (2023). *American Driving Survey: 2022*. AAA Foundation for Traffic Safety. https://aaafoundation.org/wp-content/uploads/2023/09/202309_2022-AAAFTS-American-Driving-Survey-Brief_v3.pdf

Franklin, R. C., King, J. C., & R, M. (2019). A Systematic Review of Large Agriculture Vehicles Use and Crash Incidents on Public Roads. *Journal of Agromedicine*, 25(1), 14–27.
<https://doi.org/10.1080/1059924x.2019.1593275>

Garvey, P. M. (2003). Motorist comprehension of the slow-moving vehicle (SMV) emblem. *Journal of Agricultural Safety and Health*, 9(2), 159–169.
<https://doi.org/10.13031/2013.13005>

Gerberich, S. G., Robertson, L. S., Gibson, R. W., & Renier, C. (1996). An epidemiological study of roadway fatalities related to farm vehicles: United States, 1988 to 1993. *Journal of occupational and environmental medicine*, 38(11), 1135–1140.
<https://doi.org/10.1097/00043764-199611000-00013>

Ghanbari, A., Hamann, C., Jansson, S., Reyes, M., Faust, K., Cavanaugh, J., Askelson, N., & Peek-Asa, C. (2023). Predictors of rural driver self-reported passing behaviors when

- interacting with farm equipment on the roadway. *Transportation Research Interdisciplinary Perspectives*, 22, 100926. <https://doi.org/10.1016/j.trip.2023.100926>
- Glascok, L. A., Bean, T. L., Wood, R. K., Carpenter, T. G., & Holmes, R. G. (1995). A Summary of Roadway Accidents Involving Agricultural Machinery. *Journal of Agricultural Safety and Health*, 1(2), 93–104. <https://doi.org/10.13031/2013.19457>
- Greenan M et al. (2014). Not just a rural occurrence: differences in agricultural equipment crash characteristics by rural-urban crash site and proximity to town. 70
<http://dx.doi.org/10.1016/j.aap.2014.02.013>
- Greenan, M., Toussaint, M., Peek-Asa, C., Rohlman, D., & Ramirez, M. R. (2016). The effects of roadway characteristics on farm equipment crashes: a geographic information systems approach. *Injury epidemiology*, 3(1), 31. <https://doi.org/10.1186/s40621-016-0096-1>
- Greenan M et al. (2014). Not just a rural occurrence: differences in agricultural equipment crash characteristics by rural-urban crash site and proximity to town. 70.
<https://doi.org/10.1016/j.aap.2014.02.013>
- Harland, K. K., Bedford, R., Wu, H., & Ramirez, M. (2018). Prevalence of alcohol impairment and odds of a driver injury or fatality in on-road farm equipment crashes. *Traffic injury prevention*, 19(3), 230–234. <https://doi.org/10.1080/15389588.2017.1407924>
- Islam, M. M., Liu, J., Chakraborty, R., & Das, S. (2025). Evaluating crash risk factors of farm equipment vehicles on county and non-county roads using interpretable tabular deep learning (TabNet). *Accident; analysis and prevention*, 217, 108048.
<https://doi.org/10.1016/j.aap.2025.108048>

Kansas. (2012). Kansas Statutes, Chapter 8: Automobiles and Other Vehicles, § 8-1604(b).

Kansas Department Of Transportation. (2022, December 13). Kansas Drive to Zero Dashboard Storymap. ArcGIS StoryMaps; Esri.

<https://storymaps.arcgis.com/stories/01b8e784d1634e94b84ea0df67b8aea4>

Kansas Department of Transportation. (n.d.). Drive To Zero. Retrieved November 20, 2025, from <https://www.ksdot.gov/about/our-organization/divisions/transportation-safety/drive-to-zero>

Kansas Highway Patrol. (June 13, 2024). *It's a busy time for farmers in Kansas with wheat harvest beginning! The Kansas Highway Patrol would like to remind*[Facebook Post]. Facebook.

<https://www.facebook.com/photo/?fbid=879600930865043&set=a.221055380052938>

Karimi, K., & Faghri, A. (2021). Farm Vehicle Crashes on U.S. Public Roads: A Review Paper. Open Journal of Safety Science and Technology, 11(02), 34–54.

<https://doi.org/10.4236/ojsst.2021.112004>

Leigh, J. P., Du, J., & McCurdy, S. A. (2014). An estimate of the U.S. government's undercount of nonfatal occupational injuries and illnesses in agriculture. *Annals of Epidemiology*, 24(4), 254–259. <https://doi.org/10.1016/j.annepidem.2014.01.006>

Lighting and marking of agricultural equipment. (2016). *49 C.F.R. pt. 562* (81 Fed. Reg. 40533). <https://www.ecfr.gov>

Litvin, D., Southfield, I., Tapan, M., & Datta, K. (n.d.). *Automated Collision Diagrams*.

Retrieved April 7, 2026, from <https://onlinepubs.trb.org/Onlinepubs/trr/1979/706/706-006.pdf>

Luginbuhl, R. C., Jones, V. C., & Langley, R. L. (2003). Farmers' perceptions and concerns: the risks of driving farm vehicles on rural roadways in North Carolina. *Journal of agricultural safety and health*, 9(4), 327–348. <https://doi.org/10.13031/2013.15461>

Marlenga B, Doty BC, Berg RL, et al Evaluation of a policy to reduce youth tractor crashes on public roads *Injury Prevention* 2006;12:46-51. <https://doi.org/10.1136/ip.2005.008771>

Mehlhorn, S. A., Wilkin, H., Darroch, B., & D'Antoni, J. (2015). Physical Characteristics of Farm Equipment Crash Locations on Public Roads in Tennessee. *Journal of agricultural safety and health*, 21(2), 85–94. <https://doi.org/10.13031/jash.21.10607>

McFalls, M., Ramirez, M., Harland, K., Zhu, M., Morris, N. L., Hamann, C., & Peek-Asa, C. (2021). Farm vehicle crashes on public roads: Analysis of farm-level factors. *The Journal of Rural Health*, 38, 537–545. <https://doi.org/10.1111/jrh.12621>

Pate, M. L., Lawver, R. G., Smalley, S. W., Perry, D. K., Stallones, L., & Shultz, A. (2019). Agricultural Safety Education: Formative Assessment of a Curriculum Integration Strategy. *Journal of agricultural safety and health*, 25(2), 63–76. <https://doi.org/10.13031/jash.13113>

Peek-Asa, C., Sprince, N. L., Whitten, P. S., Falb, S. R., Madsen, M. D., & Zwerling, C. (2007). Characteristics of Crashes With Farm Equipment That Increase Potential for Injury. *The*

- Journal of Rural Health, 23(4), 339–347. <https://doi.org/10.1111/j.1748-0361.2007.00112.x>
- Ramirez, M., Bedford, R., Wu, H., Harland, K., Cavanaugh, J. E., & Peek-Asa, C. (2016). Lighting and marking policies are associated with reduced farm equipment-related crash rates: a policy analysis of nine Midwestern US states. *Occupational and Environmental Medicine*, 73(9), 621–626. <https://doi.org/10.1136/oemed-2016-103672>
- Ranapurwala, S. I., Mello, E. R., & Ramirez, M. R. (2016). A GIS-based Matched Case-control Study of Road Characteristics in Farm Vehicle Crashes. *Epidemiology (Cambridge, Mass.)*, 27(6), 827–834. <https://doi.org/10.1097/EDE.0000000000000542>
- Sage Research Methods. (2021, May 6). *Getting Started with Archival Research*. Methodspace. <https://researchmethodscommunity.sagepub.com/blog/getting-started-with-archival-research>
- Successful Farming. (2025). *General Public Lacks Ag Awareness -- Study*. Successful Farming. https://www.agriculture.com/news/business/general-public-lacks-ag-awareness_5-ar19417
- Tay, R. (2016). A random parameters probit model of urban and rural intersection crashes, *Accident Analysis & Prevention*, 84, 38-40 <https://doi.org/10.1016/j.aap.2015.07.013>
- Toussaint, M., Faust, K., Peek-Asa, C. and Ramirez, M. (2017), Characteristics of Farm Equipment-Related Crashes Associated With Injury in Children and Adolescents on Farm Equipment. *The Journal of Rural Health*, 33: 127-134. <https://doi.org/10.1111/jrh.12162>

Yan, L. (2016). *Handbook of research on Innovative database query processing techniques* (p. 26). Information Science Reference

Youth Safety. (2025). Kansas Agriculture Safety and Health. <https://www.k-state.edu/kash/youth-safety/nstmop/nstmop.html>

