An investigation of tractor-related farm accidents in Iowa during 1988-1990

Carol Joan Lehtola
Iowa State University

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An investigation of tractor-related farm accidents in Iowa during 1988–1990

Lehtola, Carol Joan, Ph.D.

Iowa State University, 1992
An investigation of tractor-related farm accidents in Iowa during 1988-1990

by

Carol Joan Lehtola

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of DOCTOR OF PHILOSOPHY

Department: Agricultural and Biosystems Engineering Major: Agricultural Engineering

Approved:

Signature was redacted for privacy.

In charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1992
Dedication

This thesis is dedicated to the many agricultural safety specialists who have devoted their lives to making rural America a safer place to live and work. It is through their efforts over the years and the continuous "chipping away at the issue" that has resulted in the attention and progress that is now developing.

Often they may have felt their efforts were in vain, but as the mighty oak takes years to develop after the acorn is planted, so it has been with farm safety.

I thank you for planting the acorns, it is the responsibility of the future generations to nurture and develop the oaks!
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CHAPTER I.
INTRODUCTION

The Problem

Tractors are indispensable components of the farming operation. They contribute to the farmer's increased productivity and efficiency. Tractors are the most vital, yet deadliest machine on the farm (National Coalition for Agricultural Safety and Health, 1989).

The National Safety Council annually issues a report of accidental injuries and fatalities in the United States. Agriculture is repeatedly one of the top three deadliest industries in America. Agriculture, mining, and construction are the top three with the number one position occasionally alternating between agriculture and mining.

Machinery is the number one category of agricultural accidents, with the tractor being the machine most often involved. Tractor overturns are recognized by farm rescue workers as being the most common and most often fatal type of farm accident.

An article based on Ohio farm accident data reports (Elliott-Proctor, 1991:12):

Tractor-death statistics show that the young and the old die most often, overturns are the most common type of fatal accident, and deaths are most likely to occur in the afternoon or evening in May, June, July.

Skromme (1988) prepared a report of United States Farm Accidents for 1987. In the cover letter accompanying the report, he stated:

I am sorry to report that the U.S. Farming Industry still has the worst safety record in the U.S., and very likely in the world! What can we do in the state of Iowa to reduce this horrible harvest of farm lives?

Throughout the year, frequent newspaper articles report injuries and fatalities incurred in farm-related accidents. Many of these involve tractors.
The very nature of the agricultural work setting is conducive to numerous hazardous situations. Agricultural operations involve a unique combination of factors that cause humans, machines, and the environment to interact. Additionally, social and economic pressures can cause problems. These factors are dynamic and continually changing. Unlike an industrial work setting where a person learns a skill on one machine and one operation, the farmer uses many different machines and performs many different functions over the course of a day. During the height of the season when an operation is time and weather dependent, a farmer will not take a vacation, nor will the work week be limited to 40 hours. For farms with fewer than ten employees, there are no inspections of the work setting, nor agencies giving warnings and citations for unsafe working conditions. There are no safety specialists at each site, nor are there daily or weekly safety meetings. Farmers do not control the price they get for their products; thus they cannot pass the cost of safety equipment on to the consumer. Older machines are frequently repaired with whatever "fix-up to keep it going" devices are available at the least cost and with the least time invested. Farmers, in an effort to beat the clock, may take a shield off to do a repair and not take the time to replace it if it is not necessary for the machine's operation.

The farmer deals with such things as machines, livestock, pesticides, fertilizers, weather, mud, grain dust, electricity, toxic gases, and flammable fuels on a daily basis. Unlike the industrial workplace, the farm is both the workplace and the place of residence. It also is not a restricted area as is the industrial setting. Farming involves people of all ages, diverse skill levels, and differing physical capabilities. Training for a given task or operation is often minimal or non-existent. Many farmers do not retire from using machines and tractors when they reach a certain age. Farmers are also known for their independent nature and they may be
reluctant to admit that their physical capabilities may no longer be adequate for safe machine and tractor operation. Workers would not even consider allowing a two-year old to accompany them to an industrial work place setting, yet they often allow their children to be in the vicinity of operating machines on the farm.

Each of these factors contributes to agriculture continuously being one of the three most hazardous occupations in the United States.

The Need

The Iowa State University Extension Service reported from newspaper clippings of agricultural accidents from 1988, 1989, and 1990 that tractors were involved in 40% of the agricultural accidents reported and 87 (52.7%) of the 165 fatalities (ISU Extension 1988, 1989, 1990).

No recent study has specifically analyzed the factors involved in tractor related accidents that have occurred in Iowa. To reduce the number of fatalities and mitigate the severity of injuries it is necessary to identify the factors involved. Only when causative factors are recognized can ways to prevent these incidents be considered, or in the event that an incident does occur, ways to protect the operator be examined.

This study was conducted in order that such factors could be identified and mitigation strategies be recommended.

Purpose and Objectives

The purpose of this study was to identify factors involved in tractor-related accidents in order to develop specific strategies to reduce these accidents.
The objectives of this study were:

1. To identify specific factors involved with tractor related accidents in Iowa during a three year period.
2. To analyze the potential effectiveness of possible intervention strategies.
3. To recommend effective intervention strategies.

Data Sources and Analysis Procedure

The statistics of tractor related accidents in Iowa for the three years of 1988, 1989, and 1990 were based on data from the news-clipping service used by the Iowa State University Extension Service. Follow-up information was obtained through the Iowa Department of Public Health (IDPH). Specific factors related to tractor accidents in Iowa were identified.

Accidents were categorized and examined by studying events leading to the incident. This approach enables one to determine how the accident might have been prevented, or how the severity of the outcome could have been reduced.

Operational Definitions

The following operational definitions were used for this study:

Accident: An unintentional event that leads to injuries or loss of time from performing the intended task. This includes those incidents that involved no injuries, but did result in lost time due to unavailability (downtime) of equipment.

By-stander or other: Victims involved in tractor related accidents who are not responsible for controlling (operating) the tractor. These include passengers on the tractor, people located in the vicinity of the tractor, and motor vehicle occupants.
Farm safety: The concept that farmers and farm families are entitled to the right of living and working in an environment that is not detrimental to their productivity or well-being.

Fatality: Injury resulting in death.

Injury: Damage to the body caused by contact with moving or stationary objects. The term injury can include both non-fatal and fatal events. In this study, injury refers to the non-fatal incidents; while those incidents resulting in death were specifically noted as fatalities.

Operator: The person responsible for controlling the tractor. An operator does not have to be in the operator's station on the tractor at the time of the incident.

Refurbish: To replace safety equipment originally installed at the time that a machine was manufactured.

Retrofit: To install safety equipment on machines to bring them to the level of the present state of technology. To install safety equipment where none previously existed.

Rollover protective structure (ROPS): A cab or frame for protection of the operator of an agricultural tractor for the purpose of reducing the chance of serious operator injury in the event of an overturn.

Tractor: Tractors, as defined for this study, included wheeled or tracked vehicles used to power machines or implements for agricultural operations (garden tractors were not included).
CHAPTER II.

LITERATURE REVIEW

Introduction

The team soon was in full speed. We crashed through two fences, splintering wooden gates, racing through the pasture heading toward a grove of trees. Seconds later, the galloping horses aimed for a tree, where the wagon tongue hit square, enabling the harness to rip into a hundred pieces and the team to escape. Meanwhile, I was hurtled up 15 feet into the lower branches, and from there to the ground. This resulted in a shattered elbow and broken ribs (Plambeck, 1983:23).

Farm accidents are not a new phenomenon created by modern agricultural methods. The above scenario was described in a book documenting Iowa Farm Safety in the 20th Century (Plambeck, 1983). The Iowa Farm Safety Council historian, Plambeck, recalled that experience from when he was a 14 year old boy driving a team and wagon.

This investigation of tractor-related accidents in Iowa for 1988-90 was conducted to identify causative factors in tractor related accidents in order to recommend mitigation strategies.

This literature review was conducted for the purpose of reviewing the research that has been done in order to identify research needs for the mitigation of tractor-related injuries. The following topics were investigated: agricultural safety; injury intervention strategies; agricultural safety studies combining education and engineering; tractor safety; and rollover protection for operators.

Agricultural Safety

Accident Facts, an annual publication of the National Safety Council (NSC), consistently reports agriculture as being one of the deadliest industries, along with mining and construction. For 1989 (NSC, 1990), agriculture had a death rate of 40 per 100,000 workers. Mining
reported an accident death rate of 43 and construction 32, while the death rate for all industries combined was 9 per 100,000 workers.

Table 1 presents a comparison of agriculture with other industries, as well as a comparison of agriculture over the years from 1945 through 1989. This table indicates that agriculture has shown the least improvement in reducing worker deaths over the years. These numbers only represent deaths from acute injuries and do not include deaths from chronic causes or agriculturally related illnesses.

Table 1. Worker death rates in the United States\textsuperscript{*}

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<td>All Industry</td>
<td>31</td>
<td>27</td>
<td>24</td>
<td>21</td>
<td>20</td>
<td>18</td>
<td>15</td>
<td>13</td>
<td>11</td>
<td>9</td>
<td>72</td>
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<td>Agriculture</td>
<td>53</td>
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<td>55</td>
<td>58</td>
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<td>58</td>
<td>61</td>
<td>49</td>
<td>40</td>
<td>24</td>
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<tr>
<td>Construction</td>
<td>127</td>
<td>93</td>
<td>73</td>
<td>69</td>
<td>73</td>
<td>61</td>
<td>61</td>
<td>45</td>
<td>37</td>
<td>32</td>
<td>74</td>
</tr>
<tr>
<td>Mining</td>
<td>187</td>
<td>110</td>
<td>104</td>
<td>144</td>
<td>108</td>
<td>100</td>
<td>63</td>
<td>50</td>
<td>50</td>
<td>43</td>
<td>77</td>
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<tr>
<td>Manufacturing</td>
<td>19</td>
<td>17</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>6</td>
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Skromme (1990:2)
Notes: OSHA law began in 1970 except in Agriculture
ROPS first sold in United States in October 1967
*From National Safety Council records and corrected after 10 years

One factor contributing to agriculture's poor safety record is the low level of funding and support for occupational safety in the agricultural sector. The National Coalition for Agricultural Safety and Health (1989) Report to the Nation summarized the federal money spent on occupational safety as reported by Purschwitz and Field. Table 2 shows that
federal dollars spent on occupational safety are considerably less than for other industries.

These 1985 National Safety Council estimates indicate that 30 cents per worker was invested for occupational safety of farmers, while $182 was spent for each miner.

Table 2. Federal dollars spent on occupational safety

<table>
<thead>
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<th>Industrial Sector</th>
<th>$/Worker</th>
<th>$/Death</th>
<th>$/Disabling Injury</th>
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<tr>
<td>Agriculture</td>
<td>0.30</td>
<td>606.25</td>
<td>5.71</td>
</tr>
<tr>
<td>Mining</td>
<td>181.68</td>
<td>363,366.00</td>
<td>542.00</td>
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<tr>
<td>All industries</td>
<td>4.34</td>
<td>39,769.57</td>
<td>230.66</td>
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National Coalition for Agricultural Safety and Health (1989:3)

Differences between agriculture and other industries

America's agricultural workplace must be recognized as being different from a typical industrial work-setting. Many factors contribute to this uniqueness. Aherin et al. (1990) summarized 6 factors affecting agricultural safety in a paper presented at a meeting of the American Society of Agricultural Engineers (ASAE). The factors they noted included (Aherin et al., 1990:2-4):

1. Geographical dispersion of a small percentage of the population. Farms are geographically dispersed over a large portion of the country and involve only about 2% of the U.S. population. Farm size varies from an average size of 11 acres in New Jersey to an average of 3,781 acres in Wyoming. This dispersion of farms and people makes contact for safety education and enforcement of safety legislation extremely difficult.

2. Economic influences. The cost associated with farm safety practices is borne solely by the farmer. Costs of safety practices in industry are ultimately borne by the consumer. Time is also an economic influence. Many farming tasks need to be performed in a small window of time to maximize productivity. This pressure can lead to oversights that can lead to accidents.
3. Children as workers and on work sites. Most people working on farms live there as well. Since the work site and home site are one and the same, children are involved in this industrial setting in both work and play.

4. Aged workers. Farm workers do not incur a particular retirement age. Aged workers are an important consideration in agriculture as the average age of U.S. farm operators is 52, with 21% of farm operators age 65 or older. Injury statistics show that farm workers age 65 and over have between two and three times the rate of injury, per number of workers, when compared to other age groups. These workers are vulnerable to accidents due to decreases in sensory capabilities, information processing and decision making, and physical and musculoskeletal characteristics.

5. Stress. Farming is considered one of the top ten most stressful occupations. Fear and worry can arise from unstable markets, competition, and day-to-day economic concerns. Farmers also lack control over several factors that can affect productivity. Individual reactions to stress can cause decreases in attention, reaction time, and accuracy and judgement in decision making, leading to accidents.

6. Legislation and farm safety. Laws and regulations that have been directed at occupational and health exposures on farms have never been extensive or comprehensive. The Occupational Safety and Health Act (OSHA) was established by Congress in 1971 "to assure so far as possible every workingman and woman in the Nation safe and healthy working conditions and to preserve our human resources." But a congressional amendment to the Act in 1977, which was strongly supported by major farm organizations, prohibits the enforcement of OSHA regulations on farms with 10 or fewer employees. This affects nearly 90% of the farms and ranches in the U.S.

The Fair Labor Standards Act for Agricultural and Child Labor requires 14 and 15 year old children to obtain a certificate for completing a Hazardous Occupation Training Program before operating heavy machinery for hire. [This is not required for children who work on their home farm]. Farmers are not punished for lack of compliance with this law.

There is essentially no occupational safety and health legislation that extends to farm family members who are the most prevalent component of the work force in production agriculture.

Additional factors contributing to the uniqueness of agriculture include the interface of the environment, item worked with (i.e., machine or animal) and the person.

The interrelationship and complexity of these factors was exemplified in the following scenario provided by Murphy (1979:2).
It's late in the planting season; a coming rainstorm is threatening to keep a farmer from getting his seed corn in the ground. So he makes those hillside turns a little faster. He hurries and gets sloppy handling his pesticides. He hasn't time for a break, so he lights his cigarette while fueling his tractor. Because he has only a few more rounds, he keeps going while the lightning bolts keep getting closer. And, because it's now pouring down rain, he heads for the farmstead at full throttle over a rough, bumpy road with deep drainage ditches on both sides.

Murphy further describes other contributing factors (1979:2):

Farmers are known to work from sun-up to sunset and beyond, getting the crop in or getting it harvested. Modern machines are big, powerful, and complicated. Often the farmer has to become his own field mechanic to keep these machines operating. With gears meshing, knives slashing, rollers collecting, the untrained, hurried, self-made mechanic is a high risk for an accident.

Murphy (1979:2) quotes from Kepner et al. (1972):

In their book, *Principles of Farm Machinery*, they state, "technological advances have greatly decreased man's physical burden through use of machines, but man's mental work has been increased. The man who operates modern farm equipment must make many decisions and perform functions to use the machines properly. The demand for more decisions may result in mistakes that lead to serious accidents."

Safety practices are not only influenced by the physical environment but by the social environment as well. This concept is summarized by Murphy as follows (1979:3):

For years society has expected the farmer to work in this [hazardous] environment without complaining. "Society has come to expect a farmer to be a tough, self-made, independent, and rugged individual" (Jepsen, 1976). Using safety equipment and following safety practices goes against the grain of many of these individuals. As Smith (1977) put it, "If a farmer tried to improve the comfort and safety of his equipment, he was criticized by his neighbors of being unmanly or being a city slicker."

Agricultural hazards

Agricultural machines have been identified as the primary injury causing agent by the Iowa Department of Public Health (IDPH)(1991), accounting for 44.6% of agriculture's 83 fatalities in Iowa in 1990, and 32.4% of the total (2,143) agricultural injuries reported. Tractor-related accidents were included in the machinery category. Working with livestock accounted for 16.8% of the total injuries and 3.6% of the fatalities. The IDPH total numbers differ from the
Extension Service values, since the IDPH includes some additional categories, e.g., suicides, recreational, and hunting.

Categorizing agricultural accidents is not as simple as it may seem. Five major sources of Agricultural accidents, nationally, were reported to be (Deere and Co., 1987:3):

1. Farm machinery, 17.6%
2. Animals, 16.9%
3. Hand tools, 7.5%
4. Power tools, 4.8%
5. Truck/vehicle, 14.3%.

The IDPH 1991 report notes that slips/falls accounted for 11.3% of the injuries. This situation is complicated in the agricultural setting by what one may slip or fall into. A recent example that made national headlines involved John Thompson of Hurdsfield, N.D. (Pantera, 1992). John had both of his arms reattached after he had had them torn off by a power-take-off (PTO) shaft. The newspaper article stated, "He fell back and he grabbed for something to catch him and he grabbed hold of the PTO."

In addition to working with a variety of equipment, under a variety of conditions, the farmer is also subject to chronic diseases that have been found to be agriculturally related. These result from exposures to chemicals, vibrations, noises, dusts, and gases (NCASH, 1989).

Recognition of agriculture as hazardous

The Surgeon General of the United States has recognized that there is a problem; therefore a national conference on Agricultural Safety and Health was held in May, 1991, at Des Moines, Iowa. The goal of this conference was to develop local action for a national problem. Dr.
Antonia Novello, (1991) Surgeon General of the United States stated in a letter to conference participants,

Because of agriculture’s diversity and geographic dispersion, we must depend on local action to “deal practically with the problem.” With this in mind, we are convened here to build a coalition for local action.

Emphasis was focused on the necessity for agricultural safety and health policies to be developed at the community level based on local issues and needs.

Dr. Novello also quoted comments Dr. Alice Hamilton, the first physician in the U.S. to dedicate her career to occupational health, had made in 1925 regarding the first Surgeon General’s Conference addressing occupational health issues. These comments were appropriate for the 1991 Agricultural Safety and Health Conference as well. In 1925 Dr. Hamilton stated:

It was to me both surprising and heartening to see [men] of such widely separated backgrounds and interests...meet in a spirit of reasonableness and a genuine desire to get at the real facts and deal practically with the problem.

The importance of community involvement and the development of multi-disciplinary coalitions has been summarized by others as follows:

It was recognized in 1924 by Beard (1924:5-6) that

A continuous educational program and a live safety organization in which all civic agencies are represented constitute the only effective means of reducing the number of accidental deaths in any community.

Steffen (1990:99) recommended that:

Federal, state and local governments, as well as private organizations and industry, should encourage the formation of coalitions between current organizations working in the area of farm safety, to maximize the benefits of present and future resources. Health organizations, such as local doctors, clinics, hospitals and emergency organizations should be encouraged to take an active role in farm safety education.

Some of these recommendations are presently being implemented in Iowa. In 1990 the Iowa Legislature mandated that a center be established for the purpose of efficiently utilizing
Iowa’s farm safety resources. The annual report issued by the Iowa Center for Agricultural Safety and Health (1992) stated:

The mission of Iowa’s Center for Agricultural Safety and Health (I-CASH) is to coordinate and focus the state’s resources to establish programs that improve the health and safety of farm families, farm workers, and the agricultural community. I-CASH is a partnership of The University of Iowa, Iowa State University, the Iowa Department of Public Health and the Iowa Department of Agriculture and Land Stewardship.

One of the five target areas of emphasis selected by I-CASH is the prevention of tractor and farm machinery injuries and fatalities.

Iowa also has a network of hospitals that are promoting agricultural health and safety and are providing these services to participating farmers. This program is conducted through the Iowa Health and Safety Service Program (IA-HASSP) which is coordinated through The University of Iowa Institute of Agricultural Medicine and Occupational Health.

**Intervention Strategies**

Aherin et al. (1990) conducted a literature search of injury control strategies that have been used in non-agricultural settings, as well as those that have been applied to the agricultural setting. They summarized this review in an ASAE paper. Key points include (Aherin et al., 1990:4-6):

1. Three E Approach - This approach was introduced in the early 1900’s and involves the use of engineering, education, and enforcement to control accidents. The Three E approach was very successful in the beginning. The effectiveness of the [exclusive use] of this approach became limited. Few current academic or professionally trained safety and health experts still use the Three E approach [as their only guide] for accident or injury control.

2. Human Factors Engineering (HFE) - This methodology focuses on the design of tools, machines, jobs, operations, and environments so that they match human capabilities and limitations. The National Safety Council credits a large part of the reduction in occupational work death rates to the application of HFE principles. However, HFE application requires control over subjects, machines, and environments that may not
exist in some workplaces. Agriculture is perhaps the best example of an industry not conducive to typical work force or workplace controls.

3. Public Health Approach - This approach uses the science of epidemiology as the cornerstone for understanding, preventing, and controlling accidents and injuries. The central concept of injury causation is the interaction of the host, the agent and the environment. Only in the past few decades has the public health profession taken an active interest in injury prevention.

The success of epidemiology in disease prevention has had a far reaching effect on human health. Whether it can have the same large scale success with injury problems remains to be seen. Potential problems with the wholesale application of epidemiological principles to injury prevention are first, injuries have much longer chains of causation than do most diseases, secondly, past successes of disease epidemiology stem primarily from interventions between undesirable outcomes and undesirable behaviors. Because injuries are often the result of behaviors that individuals consider desirable, the motivation to change or alter behavior is missing. A third problem is that many other successes of epidemiology have resulted from a one time application of a countermeasure. For instance, many diseases are controlled by means of a single vaccination. It is not likely that there will ever be a vaccination to protect against injuries.

4. Current strategy - The current approach to injury control has been evolving for the past 20 years, and only today are the concepts and principles gaining wide publicity and acceptance. This approach combines empirically proven principles and concepts of HFE and epidemiology with historically learned lessons from previous injury control approaches. The National Academy of Science and National Committee for Injury Prevention and Control found three distinct means for achieving safety and health. The three means are a) educating and persuading individuals, b) laws and regulations directed at individuals, and c) policies directed at providing automatic protection from agents and vehicles (paths) of injury. There is little disagreement among recognized safety and health professionals that effective injury control for most safety problems requires some mix of all three means.

5. Agricultural approach - The past and current efforts for modifying farm worker safety behavior can be grouped into education, legislative and engineering activities.

Aherin et al. (1990:6-8) continue by providing insights into some of the weaknesses of the Three E’s in application to agricultural safety.

Education - There are few studies in the literature that address whether or not specific educational programs have been effective in reducing the incidence of farm injuries. However, a couple of studies were identified where a comprehensive farm injury prevention program was implemented with large farming operations that did result in significant reduction of injury experience. These programs followed an industrial safety program
model that included five key elements: management commitment, a written safety policy, an award and incentive program, safety committee involvement, and continuous feedback to employees. Safety training and education were an integral part of the overall program.

Engineering - The promulgation of safety and other standards by the ASAE is the primary means by which the manufacturing industry has produced safer tractors, machinery, and related products. This process is voluntary and involves a number of interested groups. The accommodation of a variety of industry, academic, and public interest viewpoints means it usually takes years to get a standard or engineering practice adopted. The hazard reduction possibilities of some engineering standards are rendered almost useless in the workplace because the manufacturer loses control of the product once it enters the market place.

Research in agricultural product safety engineering does not seem to be a priority with any public sector in the U.S. Safety engineering is not a priority within the Agricultural Research Service, the major research branch of the United States Department of Agriculture. Agricultural Engineering departments at land grant universities do not appear to be actively involved in product safety engineering. The lack of an aggressive and visible safety engineering research program to reduce agricultural machinery hazards appears to be a major stumbling block in reducing the level of risk associated with farm machinery and equipment.

Legislation (enforcement) - There is little safety legislation that directly impacts the level of risk in the farm work environment, or the safety behavior of farm workers. Those standards that do exist either do not affect most agricultural workers or are not effectively enforced.

Agricultural Safety Studies Combining Engineering and Education

Several agricultural safety studies provided relevant information for this study. These studies dealt simultaneously with the education and engineering components of agricultural injury intervention. Summaries of these studies are included in this section of the literature review.

An annotated bibliography of agricultural safety theses and dissertations was compiled by Lehtola (1988).

The earliest thesis found was written by Shanks in 1931. This research was done at the Department of Agricultural Engineering at Iowa State University in Ames. His study included
data collection, targeting of the causes and problem areas, and looking at the existing legislation relating to farm accidents (i.e., worker's compensation). He then used the information obtained to develop accident prevention devices, to determine how safety education could be brought to rural people, and recommended a safety code for the design and utilization of farm machinery.

Many of the items identified as problem areas in 1931 are still relevant 60 years later.

Examples quoted directly from Shanks' thesis include:

Agricultural machines have been sold and used without the safety devices required on other industrial machines (p. 7).

The conclusion of this association [the National Safety Council] was that more interest should be aroused in the problem through farmers' organizations and through the schools (p. 11).

Consequently statistical records are lacking and as a result of this condition no complete statistics are possible as a basis for this study (p. 12).

This shows conclusively one of the features of farm accidents, namely, that the ratio of fatalities for children under 18 years in comparison with those between 18 and 20 is greater than in other industries. This is due doubtless to uncontrolled home employment more than to any special hazard but constitutes one of the special problems of farm accident prevention (p. 26-27).

The presence of guards not only reduces the hazards but also helps to make the worker safety conscious and it is difficult to make an effective educational appeal without first undertaking mechanical guarding (p. 71).

Some general principles arising out of this study may first be mentioned. 1. Guards of farm machines should, if at all possible, be an integral part of the design rather than attachments. This would result in lower cost in most cases and also ensure use, for under farm conditions inspection of safety devices is impractical and without inspection attached guards are often removed. 2. The guard should not hamper the operation of the machine. This is an essential requirement for attached guards, if they are to remain in use (p. 73).

Tractor accidents were due to the operator attempting to make adjustments while the tractor was in motion. Another cause of accidents was slipping or falling from the seat or platform (p. 86).

The accidents due to this combination [tractor and hauled machine] are among the most serious. Backing up to a load and failing to release the clutch in time, being pinned against the tractor by projecting or overhanging parts of the hauled machine or attempting to make
a coupling between the drawbar of the tractor and the hitch of the load are all hazards of this combination (p. 88).

Since no information existed regarding the distance a tractor traveled after the clutch was released, Shanks conducted a series of mechanical tests. He concluded (p. 88), that the operator who fell from the seat of a tractor that was pulling a load might not be saved by an automatic clutch release operated by his weight on the seat or platform. His tests showed that in the amount of time required to activate such a device, the operator would already be in trouble.

Relative to education for agricultural safety, Shanks noted (p. 112):

Adequate guarding of machines is often difficult, usually expensive and involves technical, operating or legal problems, all of which delay the solution of the problem of mechanical safeguarding, but a program of safety education knows no such limitations.

Safety Education in Agriculture cannot follow the relatively simple plans evolved for Industry. In a factory, the hazards are known as the result of recorded experience, the executives are convinced that safety education pays, and the persons to be educated are easily and effectively reached as a result of their control through the factory organization.

Johnson (1953), in a thesis examining fatal accidents of rural residents of Iowa, made the assumption that a person cannot consciously avoid a fatal accident unless he is aware that a hazard does exist. Many hazards in farming may not be readily apparent to the person operating farm machinery. A farmer is required to assume the role of safety engineer for his farming industry workplace, frequently without an understanding of the hazards involved.

The necessity for teaching hazard identification to farmers was reinforced during a 1990 offering of an agricultural safety course for Iowa State University (ISU) off-campus students. The enrollment, 68 adult students ages 22-62, indicated peoples’ desire to learn about hazards and how to correct them. Students commented to this researcher (Lehtola and Boyd, 1991) that inherently they knew that farming was dangerous, but it took someone pointing out the hazards
and the reasons why they were hazards to make them aware and conscious of those hazards. People cannot make decisions on hazard correction or safe operation if they do not know what their options are.

Steffen (1990) noted that using sound educational methods that work when teaching safety is vital; however determining those methods is more difficult. He supported the premise that mere memorization without understanding is not the most effective method. He quoted Miller (1982:287):

Memorization of safety rules represents a low level of cognitive learning, and it is doubtful if this kind of instruction is the most effective in bringing about changed safety behavior patterns.

Thus methods recommended for farm safety education include participation and involvement. This approach was used by Lehtola and Boyd (1992) in the teaching strategies used for a college level adult agricultural safety course. The objectives of the course were for the students to:

1. Identify agricultural hazards and risks.
2. Implement measures to reduce or eliminate agricultural hazards and risks.
3. Understand the implications of negligence and liability.
4. Participate in safety related activities.

These objectives were met by promoting active student participation and involvement through the use of case studies, simulations, and developing a technological solution to a real world safety problem.

Lehtola and Boyd (1992:32) indicated that:

Educational methods of involvement, participation, case studies, and simulations were incorporated in order to develop correct behavior for emergency or hazardous situations. In an emergency, people tend to follow reflex actions. The ultimate safety training incorporates correct behavior as the reflex action. People respond well when taught the
scientific principles and reasons why a situation poses a hazard. They are more likely to develop correct behavior if they understand why in contrast to just being told not to do something.

Murphy's (1980) discussion of human behavior and agricultural safety illustrates the validity of the above mentioned methods and premise. Murphy stated (1980:90):

Unless you subscribe to the discredited theory that all people are suicidal in nature, one would think that a higher value would be placed on the alternative that would protect decision-makers. And it surely would if all safety decisions were made in a rational, cool, detached, and objective manner. But this simply is not the case in real life. Many of the decisions involving safety behavior which lead to accidents are made in moments of high stress, considerable aggravation, and acute uncertainty.

The result is that safety decisions are often made while the decision maker is anything but a rational being.

Massie (1979) analyzed the National Safety Council’s Farm Accident Survey conducted in Maryland in 1974. His data indicated that many agriculturally-related accidents occurred in familiar surroundings. He felt that people do not think in terms of hazards when they are working with familiar things.

Two relationships resulting from the Maryland study were:

1. When the accident involved a thing, the victim was likely to have been with the thing at the time of the accident one hour or less.

2. Individuals involved in accidents with things were likely to have more than 999 days experience with the thing involved.

Perceptions of hazards often do not match the realities, as evidenced by the Iowa Farm and Rural Life Poll (Lasley and Kettner, 1989). The survey was completed and returned by 2,016 Iowa farm families. Farmers surveyed perceived insecticides as the most hazardous item they worked with and tractors as least hazardous. Yet, for those reporting that they had had an
accident, farm machinery was the number one item involved, with tractors being fourth. No
acute incidents involving insecticides were reported.

These data support the need for teaching hazard identification and safe operation of even the
most familiar of equipment and surroundings. It must also be recognized that hazard
identification and safe operating procedures need to be taught for all age and skill levels. The
time to train a person in the correct and safe practices for any job is at the beginning of the
learning process.

Steffen (1990) made use of the Delphi technique in determining the needs of a farm safety
program for youth. Based on his research, he determined the following objectives were needed
for a farm safety awareness program targeted at youth (Steffen, 1990:93-94):

1. To develop the skills necessary to recognize safety hazards.
2. To develop respect for safety hazards.
3. To understand causes of accidents and near misses.
4. To identify the typical farm hazards children are exposed to.
5. To encourage the development of procedures and solutions for eliminating hazards.
6. To dramatize typical farm accident situations.
7. To create a sense of responsibility for the youth as a "safety guardian" on his/her farm.
8. To dramatize or explain the environmental and emotional conditions which increase
   accident potential.
9. To respect limits set by parents.
10. To demonstrate human limitations and reaction time.
11. To identify emergency procedures and basic first aid steps.
12. To identify the six leading causes of accidental death.
13. To develop sensitivity to the disabilities and changes in lifestyle that may result from
    typical farm accidents.
14. To work with the media to promote farm safety.

Participants in Steffen's study also ranked tractor and machinery safety as the two highest
priority topics to be included, with tractor safety being the top priority. Participants indicated
that hands-on activities were ranked as the most effective method in teaching safety.

The analysis by Williams (1983) of the National Safety Council's (NSC) 1981 survey of
Iowa farm families showed that the level of annual exposure to agricultural work best accounts
A significant finding in Williams' (1983:56) study was the strong correlation between the level of annual exposure and agricultural accident occurrence. He stated:

This suggests that one approach to agricultural accident reduction is to reduce the actual risk associated with hazardous agricultural activities. This can most effectively be done by educating agricultural workers in the importance of safety features on agricultural equipment and facilities in preventing accidents. In addition, there is a need for specific information regarding recognition and elimination of hazards associated with the agricultural work environment. Individuals, such as engineers, who design components and systems for agricultural operations need to understand their important role in preventing accidents.

Silletto's (1976) study for the purpose of identifying Iowa farm accidents and determining educational implications for the agricultural population found there was a significant difference in accident frequency among types of farms, with dairy and hog farms reporting more accidents than other types of farms.

Williams (1983:13) noted the conclusions of a 1975 Ohio farm accident study: "There is increasing evidence to support the hypothesis that exposure and the potential hazardousness of an activity are directly related to accident occurrence."

This conclusion supported Sillettos' (1976) finding of more accidents on dairy and hog farms. Dairy and hog farming operations require daily work activities.

Iowa's dairy operations are traditionally found in areas where the topography or land quality is less suitable for cropping practices. Statistics in the Iowa Census of Agriculture (1987) support this premise. Counties in Iowa with steep hills, rivers, and little soil depth to rock, account for the majority of Iowa's dairy operations.

McKnight (1984) conducted a comprehensive study analyzing national data for the six year period of 1975-81. The data were obtained from the Consumer Product Safety Commission for
the purpose of determining the extent and characteristics of fatalities incurred while using farm equipment. He reported 3,229 farm-related deaths; 75% of these were associated with tractors and 50% of the tractor-related deaths were associated with overturns. Since this study was conducted through the Johns Hopkins Medical School, clinical aspects of the fatalities were also investigated. McKnight estimated that one-third of all deaths to adults could have been prevented if three available, yet under-utilized injury control devices had been installed. These included tractor rollover protective structures (ROPS), guarding on auger intake ports, and power take-off shielding.

McKnight recommended that injury intervention needs to be approached from the community level and responsible public solutions to machinery hazards need to be developed. Presently, in the 1990's, it is recognized that injury interventions need to be conducted at community levels analogous to the public health models that have been successfully used for decades (Hawk, 1991; Novello, 1991).

Schaefer (1986) studied safety practices used by farmers in Louisiana. His data also supports the premise that farmers are exposed to a variety of work situations and must have a working knowledge of varied safety practices.

Based on a content analysis of the completed theses that were studied and described in Lehtola's (1988:52-53) bibliography, the following implications for education and engineering for agricultural safety were noted:

* Many farm accidents involve general things, especially slips and falls (this is compounded if one falls into a machine). General safety programs and reminders are also necessary in agricultural safety training and education.

* Safety programs and a decrease in accidents follow a 3-year cycle. As a specific hazard is emphasized accidents will lessen; when the program is removed, the number of accidents will increase. People need to be reminded on a cyclic basis.
Safety educators must be aware and alert, not only to change programs with changing needs, but also to recognize hazards that could be designed out of the system of the human, environment, and machine interface. It is necessary to be knowledgeable about new machines. New technology replaces old hazard situations with new ones. Each machine has new operations and hazards to be learned and recognized by the operator.

* Safety must be an integral part of a person's daily activities.

* People involved in agriculture need to be able to identify hazardous situations and the safest way of doing a job. This relates to the familiar as well as the unfamiliar. It is often more difficult to recognize hazardous situations when working in familiar surroundings.

* Safety education must be presented in such a way as to help people develop a positive attitude about safety practices and safety regulations which are for the good of the workers.

* Safety programs need to be developed and presented by safety educators sensitive to the needs of the intended audience.

* Special emphasis for education and training should be placed on safe operating practices when using machines with the highest accident rates, such as tractors, elevators, combines, balers, and wagons.

* Living is not free of hazards.

* A positive reward approach to the problem of accident prevention has better results than a negative punitive approach.

* Periods of high incidence of accidents need to be recognized and emphasized.

* People who may be affected by accidents should participate in the development of programs.

* Instructors of farm safety education programs should be made aware of what teaching aids and resources are available to them.

* Farm safety audio-visual materials need to be continuously updated and made available at a minimum cost to educators. Farm organizations, implement dealers, and agricultural industries should be encouraged to sponsor these materials.

* All drivers should be educated as to hazards of farm tractors and farm machinery on public roads. Drivers should understand and be aware of the farm operator's situation of noise, lack of visibility, and the speed differential between farm machinery and other traffic.
Implications identified for engineering for improved safety included:

* The development of devices that can be used to shut-off a machine from a distance or to be located at easily convenient and accessible locations along the machine. Frequently a machine is not shut off for the basic reason that it is inconvenient for the operator to walk around the machine and enter the operator's station to shut it off.

* The development of reverse mechanisms to be used for unplugging the machine when it gets plugged during a field operation.

* Engineers must understand the operation of the mechanism. Engineers need to be aware of the entire operator, machine, and environment interface. Design of safety devices, shields, and guards, can not override the function or actual utilization of the machine (e.g., if a tractor is designed to shut off when a farmer leaves the seat, it will be such an inconvenience in the actual use of the equipment, the farmer will soon find a way to over-ride the system). Some safety devices can induce hazardous situations when they fail or are misused.

Tractor Safety

Hazards of tractor operation

The operator, machine, environment interface relevant to tractor operation was stated by Knapp (1966:178) as follows:

Man [operator] is considered as the sum of his physical being, including all handicaps, and his learned [from personal experience and education] and automatic responses. Just as real, but unapparent, are psychological and physiological aspects. Mental strains of "getting the job done" and preoccupation with weather, coupled with physical factors of heat, weariness, vibration, and noise reduce his mental capabilities. Many environmental factors surrounding the man are severe enough to cause both temporary and permanent internal physical damage.

Man and machine are brought together in an environmental situation in practical farm use. This is the utilization of the tractor from the customary work of pulling tillage tools to pushing autos out of ditches, positioning elevators, chasing cows, and transporting people. It serves as a power source for innumerable devices supposedly designed to make farming easier and often ordered from a catalog. In many instances these additions to the tractor create real safety hazards because they radically change the stability of the tractor. Such changes are not apparent to the user, for he is unaware of the intent of tractor design and unprepared to cope with unexpected tractor reactions.

The reaction of a machine to a changing job situation is not automatic, and the whole burden of corrective action rests upon man's varying physical and mental limits. His
actions are further subjected to such stresses as may be placed on him by the machine he is operating. In addition, the operator is faced with the environmental factors of weather and terrain, which are constantly changing.

A five-year study of all workplace fatalities involving machines, conducted by the National Institute for Occupational Safety and Health (NIOSH), reported that 43.8% of the fatalities involved agricultural machines. Sixty-nine percent of the fatalities involving agricultural machines were tractor-related (Etherton, et al., 1991).

Murphy (1990) researched twenty years of tractor accident statistics for a presentation to the American Society of Agricultural Engineers (ASAE). He reviewed tractor accident statistics and studies that have appeared in the literature over the past 20 years. Regarding the studies found, he stated (Murphy, 1990:1): "Only a few studies specifically singling out tractor accidents were located; these are nearly all reports of fatal accidents and are over 25 years old."

Murphy further stated (p. 2):

Tractors remain the predominant agent of injury for fatal farm work accidents while accounting for a much smaller percentage of non-fatal farm accidents. Tractor related accidents are approximately one-third to one-half of all fatal farm injuries but only constitute about five to ten percent of total non-fatal farm injuries.

His study showed that the type of fatal tractor accident has not changed appreciably over the past 20 years. He summarized types and percentages of tractor related fatalities based on data from the National Safety Council. This information is shown in Table 3.

Murphy presented NSC data that did show that the fatality rate per 100,000 tractors decreased by 50% from 1970 to 1989, with a 1970 rate of 14.9 and a 1989 rate of 7.2. It was noted there were no published data giving specific reasons for this reduction. The use of the rollover protective structure (ROPS) would be one factor. Murphy theorizes that possible
Table 3. Fatal tractor accident type

<table>
<thead>
<tr>
<th></th>
<th>1969-73</th>
<th>1985-89</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overturn</td>
<td>54%</td>
<td>49%</td>
</tr>
<tr>
<td>Runover</td>
<td>24%</td>
<td>23%</td>
</tr>
<tr>
<td>PTO</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>16%</td>
<td>22%</td>
</tr>
<tr>
<td>Not stated</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Murphy (1990:2)

reasons include generally safer tractors due to design improvements such as better steering, visibility, and braking, along with changes in tractor usage.

Murphy’s (1990:5) study resulted in the following conclusions:

1. Fatal tractor accidents, per 100,000 tractors, have declined 50 percent over the past 20 years.

2. There are no data to support any hypothesis as to why this reduction has occurred.

3. A 50 percent reduction over 20 years is not considered satisfactory progress by many non-agricultural groups and individuals, or by some agricultural groups.

4. Despite this reduction, tractors are still the major agent of injury for fatal farm accidents. The major types of fatal accident incidents also remain unchanged.

5. The involvement of youth in fatal tractor accidents has remained relatively unchanged over the last 20 years while the involvement of aged persons seems to have increased.

6. There have been no comprehensive studies or reviews of tractor accident problems since 1971 and 1972.

7. The fundamental problem of inadequate data to accurately and reliably assess tractor safety issues has not progressed beyond the limitations identified 20 years ago.

8. The generally descriptive type of data that has been collected and analyzed for well over 20 years gives little, if any, clues as to how the reduction of serious tractor accidents may be accelerated.

9. Unless and until research support agencies invest the resources necessary to collect detailed exposure data, trends in tractor safety statistics and progress will remain nebulous.
A 1975 Iowa Extension publication (Wardle and Hull, 1975) shows the manner of occurrence of fatal tractor accidents in Iowa for the 25 years of 1947-1971. The total number of tractor fatalities during that period was 1,327. They were divided into the categories shown in Table 4. A comparison is also made with the data they had documented for the first 10 years of the study.

Table 4. Manner of occurrence of fatal tractor accidents in Iowa 1947-1971

<table>
<thead>
<tr>
<th>Category</th>
<th>1947-1956 (10 years)</th>
<th>1957-71 (15 years)</th>
<th>1947-71 (25 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overturned</td>
<td>272</td>
<td>546</td>
<td>818</td>
</tr>
<tr>
<td>Driver/rider fell or jumped from</td>
<td>48</td>
<td>77</td>
<td>125</td>
</tr>
<tr>
<td>Run over (not driver or rider)</td>
<td>39</td>
<td>58</td>
<td>97</td>
</tr>
<tr>
<td>Collision with motor vehicle</td>
<td>29</td>
<td>57</td>
<td>86</td>
</tr>
<tr>
<td>Crushed between tractor and object</td>
<td>2</td>
<td>28</td>
<td>50</td>
</tr>
<tr>
<td>Caught on PTO, belt, wheel</td>
<td>19</td>
<td>46</td>
<td>65</td>
</tr>
<tr>
<td>Not stated</td>
<td>16</td>
<td>41</td>
<td>57</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>454</td>
<td>873</td>
<td>1327</td>
</tr>
</tbody>
</table>

This was the last report to provide information on tractor related accidents in Iowa. The study did not detail types of tractors and other accident specifics.

Wardle and Hull referred to a 1945 Iowa tractor population of 151,137 and 282,867 in 1971. Unfortunately, a breakdown of tractor related fatalities per year was not provided, thus one cannot determine the annual rate per 100,000 tractors.

Intervention Strategies

Two areas of consideration for reducing tractor related fatalities were examined in a study done by McClure (1961) of fatal tractor accidents in Ohio:
1. Making the machine safer through design

2. Making the operator safer through education.

McClure recommended that educational efforts should be directed toward preventing injury during a mishap as well as avoiding the mishap in the first place. When hazardous situations cannot be avoided, the tractor operator should be trained in the best methods for safely handling the situation.

There is a tendency in safety education to focus entirely on prevention. Both prevention and preparedness need to be taught. Many hesitate to teach preparedness because they feel that implies the prevention education wasn’t effective. However, it must be recognized that accidents do happen. It is just as important to teach what to do and how to react properly in such a situation as it is to teach prevention. Murphy’s (1979) observation was that farmers with good safety attitudes are just as likely to be involved in farm accidents as those farmers with poor attitudes.

In the early 1960’s, researchers in the Agricultural Engineering Department at Ohio State University studied the criteria necessary for developing a visual device that could be effectively used for warning people of a slow moving vehicle on public roads.

Gebhart (1963) concluded that the triangular shaped SMV symbol that is in use today was the most effective of the devices tested. Since then, the SMV sign has been accepted and standardized as the universal symbol for slow moving vehicles, those traveling less than 25 miles per hour on public roads and highways. Many states do require use of the SMV sign on public roads (Deere and Co., 1987:8).
Thirty-six tractor overturns in Nebraska were analyzed for the purpose of developing performance testing procedures for protective enclosures (Baker, 1972:42). An observation made from this analysis was:

That in no case had the throttle been moved immediately prior to upset. In some situations there was not time, or drivers may not have recognized the impending danger. On all tractors involved, the throttle location was outside the maximum zone for hand operated controls established by SAE [Society of Automotive Engineers]. Perhaps the extra effort required to reach the throttle prevented such action. The indication is that the location of hand controls on tractors should be considered and improved.

Schnieder (1983:10) concluded that farm fatalities in Nebraska had been reduced over time, due to three main factors:

1. Development of protective hardware, e.g., ROPS and improved machine guarding.
2. Compliance with OSHA Safety Standards and ASAE standard S361.1.
3. Education in fatality accident prevention.

These interventions are representative of the approach referred to previously as the "3E's", those that involve engineering, enforcement, and education.

A telephone survey of 400 farmers was conducted by researchers in the Agricultural Engineering Department at the University of Nebraska in 1987 to identify factors that influenced them to make tractor-buying decisions. Grisso et al. (1988:197) stated:

Knowing what sources of information are typically used by farmers, and which are most beneficial, will enable the specialists, engineers, sales personnel, and educators to provide current and timely information in these sources...

The four sources identified as being used the most were:

1. Equipment dealers
2. Neighbors, friends, or relatives
3. Advertising literature
4. Nebraska Tractor Test Reports.
They noted that a similar study in Kansas in 1979 had dealers and neighbors also listed as the two top sources of information.

Since these are repeatedly indicated by farmers to be their information sources when making tractor-buying decisions, these sources would be likely routes of safety dissemination and implementation of intervention strategies.

The aspect of neighbors and friends being a key factor is an example of the social and peer network and the influence it does have on the adoption and acceptance of practices.

Schnieder (1970) described the work done by the University of Nebraska Agricultural Engineering Department personnel to promote tractor safety. Actual tractor roll-overs, using dummies and remote controls, were demonstrated to large audiences of people. They showed the effects of rollover without a protective structure and rollover with a protective structure.

Schnieder describes a 1968 event:

We showed something to our crowd that day that had never been shown before: the ability to keep a tractor on its wheels by proper steering. A tractor could be kept on its wheels in many situations when it was run off an embankment. If the tractor was allowed to go its own way or be steered in the direction of travel, we could keep it on its wheels without too much difficulty when run off an ordinary ditch. This procedure can be of value if there is a good ditch to steer into. This was something we were not looking for in our earlier research work, but it did show up. Hopefully we can pass this word to enough people and possibly save some lives (Schnieder, 1970:4).

Schnieder noted that effective tractor safety programs need the cooperation of many agencies:

It takes a unified voice of the manufacturer, the machinery dealer, the Department of Agricultural Engineering, and other agencies throughout the state to effectively promote tractor safety (Schnieder, 1970:8).

Dale Hull, who had served as the Extension Safety Specialist in Iowa, reported on tractor safety schools that were held. Hull noted (Plambeck, 1983:64):
It has long been recognized that a trained operator is a safer operator. Even though farmers and farm families have successfully operated tractors and equipment for several decades, the fact remains that too many operators are still unaware of the hazards that exist when operating farm tractors and equipment over agricultural land and along public highways.

Hull reported that in 1948 Wardle began a tractor operator training program for Iowa’s 4-H youths. In 1958 programs were developed for adult tractor operators, primarily males. In 1965 Wardle conducted training for farm couples (Plambeck, 1983:64):

Wardle’s one-day training programs consisted of lecture, instruction, demonstration and actual tractor operation, preferably on a race track at the local fairgrounds for a driving course.

Tractor operator training programs were also conducted specifically for women. Hull makes a valid and important point when he further states (Plambeck, 1983:64):

Farm women had often complained their husbands only wanted them to operate the tractor when they were stuck or in a difficult situation. As a result, they felt they needed the knowledge and experience to make them safe operators in times of stress. At least one fatality in Iowa occurred because a husband asked his wife to operate the farm tractor under a non-safe situation which resulted in her death from a reverse overturn.

Stability indicators

There have been studies focusing on the feasibility of stability indicators for use on agricultural tractors. These would be oriented towards providing visual or audio (i.e., alarm) feedback information to the tractor operator when the tractor is approaching the critical slope angle such that an overturn is imminent. These still need considerably more development and testing in order to provide an effective and practical solution.

In a confidential interview, one tractor manufacturer indicated they are not actively promoting the use of such mechanisms since they have found that when such alarms have been used in the logging industry, the operators use this as the limit they can achieve and still be safe, as well as they quickly learn by how much they can safely exceed this limit, rather than
using it as a warning to avoid. It is felt that operators would improperly use the warning as their safety net. With the manufacturer's concern for liability in the event that something does happen, they are not in favor of supplying or using such devices.

Research on stability indicator devices and human response times has been recently conducted and is on-going at The Pennsylvania State University. Goldberg and Parthasarathy (1989) reported on operator limitations in tractor overturn recognition and response times by simulating an impending roll situation. They based their study on the premise that tractor instability must first be perceived before a corrective response may be taken.

**Overturn prevention and operator protection**

The Rollover Protective Structure (ROPS), as defined by American Society of Agricultural Engineers Standard S383.1 (Hahn, 1989:204) is:

A cab or frame for protection of operators of wheeled agricultural tractors to reduce the chance of serious operator injury resulting from accidental upsets. The protective structure is characterized by providing space for the clearance zone inside the envelope of the structure or within a space bounded by a series of straight lines from the outer edge of the structure to any part of the tractor that might come in contact with flat ground and is capable of supporting the tractor in that position if the tractor overturns.

There have been many articles written in support of ROPS and their effectiveness. Sweden mandates ROPS on all tractors used. This includes new tractors as well as retrofitting older tractors. Springfeldt and Thorson (1987) detailed the implementation of the mandatory ROPS program and showed the resulting effects. The mandatory rules for a protective frame on new tractors became effective in 1959, the rules for retrofitting older tractors were initiated in 1965. The risk of a fatal overturn in Sweden was reduced by 90%. Fatal overturns went from a rate of 19.5 per 100,000 tractors in 1959 to a 0.5 rate per 100,000 tractors in 1978. The 0.5 rate has held constant since 1978.
Schnieder (1983:2) determined from a study of tractor related fatalities in Nebraska for 1970-1982 that:

Tractor overturn fatalities in Nebraska primarily involve the older male operator driving older model tractors not equipped with rollover protective structures. To date, there has not been one fatality in Nebraska involving tractors equipped with ROPS.

He also felt that deaths due to people being accidentally thrown or bounced from the tractor could have been prevented if the tractor were equipped with ROPS. He suggested that during the 13 years studied a total of 222 lives could have been saved if ROPS were in use.

Having a ROPS on a tractor does not prevent a rollover or necessarily reduce the number of rollover incidents. The ROPS does prevent the death or serious injury of the operator and does reduce the number of fatalities due to rollovers.

Buchele (1987) compiled a chronological summary of stability and rollover protection structure literature. This comprehensive bibliography provides historical and developmental information on the design and use of ROPS.

Buchele's bibliography indicates that a safety cab was introduced on a tractor as early as 1939. ROPS were developed and assembled for highway mowing tractors in North Dakota in 1959, with all North Dakota Highway Department tractors equipped with ROPS by 1962. Research on ROPS was conducted by the Agricultural Engineering Departments at the University of California Davis as early as 1956 and at Michigan State University in 1959. The conclusion of these research studies was that a ROPS is a safety device which is necessary to make the tractor safe for operation by farmers and other workers.

A symposium on the use of ROPS was held by the ASAE in 1962. Buchele states (1987:1), "the speakers strongly recommended the immediate adoption and installation of ROPS on agricultural tractors."
However, the history of the adoption of ROPS shows that adoption and installation were not immediate, nor has the ROPS requirement included all agricultural tractors. Thirty years later many of the same discussions are being held. MacCollum (1984:25) summarized twenty-five years of ROPS history in an article for *Professional Safety*. He placed emphasis on industry not doing anything with safety development, even though they had the technology to do so. He stated:

It proves that more emphasis needs to be placed on safety engineering at time of design and on design improvement whenever equipment develops a history of repetitious accidents. The fact that death and injury from accidents involving tractor rollover have been substantially reduced because of the installation of ROPS makes a case for greater design safety emphasis.

MacCollum further stated (p.25):

that engineering must do everything it can in removing hazards including developing physical safeguards in the design of equipment so that we do not have to rely solely upon human performance to avoid or minimize injury or damage-producing circumstances.

ROPS usage was mandated by the Occupational Safety and Health Administration (OSHA) on tractors manufactured after October 25, 1976, which would be operated by employees on farms with more than 10 employees. Farms with less than 10 employees (excluding family members) were exempted.

The development of decent weather cabs with the ROPS integrated as a part of the cab frame has led to many farmers using ROPS, not specifically purchased for overturn protection but for the comfort and protection from the elements that the cab provides. If safety features are incorporated as an integral essential component of the machine they are used and do provide protection.
Buchele indicated that in 1971 all major tractor companies were selling the two-post type ROPS as well as the ROPS in the form of safety cabs. On November 1, 1984, Deere and Co. announced they would sell only farm tractors that were equipped with ROPS.

In 1985 the ASAE Standard S318.8 stated (Buchele 1987:3-4),

Tractor roll-over protection meeting the requirements of ASAE Standard S383, Roll-over Protective Structures (ROPS) for wheeled agricultural tractors, shall be provided on wheeled agricultural tractors.

Currently, new tractors are sold equipped with ROPS, however, it is due to ASAE standards and the National Institute for Farm Safety (NIFS) recommendations, and manufacturer’s liability concerns. It is not a legal, mandatory requirement. Farmers are still known to take them off once they get the tractor home.

The National Institute for Farm Safety (NIFS) adopted the resolution that dealers refurbish equipment to the date of original manufacture, i.e., to replace missing or damaged safety items. (Note: refurbished differs from retrofit; retrofit refers to adding safety devices that weren’t present when manufactured). The refurbishing is required by law in Minnesota as of July 1991. However, the legislation and NIFS resolutions do not apply to equipment not sold through dealers, e.g., farmer-to-farmer sales and auctions. The NIFS resolutions and Minnesota law are contained in Appendix A.

Skromme (1989) compiled a report of agricultural accidents for 1987, based on data submitted by the Extension Safety Specialists in 30 states. (Iowa was included). In his cover letter he stated:

The [agricultural] death rates of three countries, the United States, England, and Germany are compared. [p. 58 of the report]
Agricultural Death Rates per 100,000 Workers

England 19.3
Germany 19.0
U.S. 56.8

Our ASAE safety standards are just as good as those in England and Germany, and the farm machines and structures produced in 1988 are just as safe as those produced in Europe. Now then, why does the U.S. have a death rate three times as high as they do?

The answer is "lack of retrofits," caused by lack of laws that mandate early use of new safety features. OSHA laws do not require retrofits [of ROPS] on tractors built before 1976.

Skromme further identified any tractor without a ROPS as a dangerous machine.

Skromme's 1987 summary of data from thirty states indicated there were 547 deaths in 1987 due to tractors, with 60% (331) due to overturn. Skromme is quite adamant about the use and requirement of ROPS. His recommendations include:

our recommendation to the USDA to add riders to their Subsidy Appropriation Bills, requiring the farmer to have a safe workplace before they obtain their subsidy check, has considerable merit and should be pushed.

He continues:

We have prepared a Safety CheckList of 3 pages, suggesting that the USDA not give the farmer his subsidy check unless he first signs this CheckList with a notary public, stating that all answers are correct. One way or another we must either get rollover protection on these tractors or have them scrapped.

He reported a conversation he had with an Arkansas Highway Maintenance supervisor about usage of their tractors. Comments relative to the importance of ROPS usage were:

They have had about 6 rollovers in the past 10 years. No driver has been killed . . . they all returned to work within 2 weeks.

They would never even THINK of using a tractor without ROPS and a very tight seatbelt. Not using a tight seatbelt is cause for dismissal.

Questions continually raised for the retrofitting of older equipment relate to the cost and who pays. Skromme (1988:53) recommends:
In many cases the farmers should pay for these retrofits if these machines were produced before technology had provided the answer, or if they opted to save money by not buying the safety feature on their new machine. In other cases the manufacturers would pay if the machines were produced after this technology was available, or if the device did not function as intended.

We want to help both the farmer and the manufacturer. A happy and healthy farmer means continued prosperity for the manufacturer, too.

Ohio State University statistics, based on newsclipping data, Elliott-Proctor (1991) indicate that 63 percent of fatal tractor accidents in Ohio are overturns, and 26 percent of the fatalities involve people older than 65. OSU agricultural engineer, Tom Carpenter, stated, (Elliott-Proctor, 1991:14):

Of all farm tasks, perhaps the most dangerous job a farmer does is mow a hillside meadow.

If a farmer has a pasture to mow, he'll often use an old, unprotected type tractor with a mower. They don't want to tear up a new tractor mowing a pasture. Also farmers often assign the task of mowing to young or elderly family members. Also in a pasture, there are ditches, stumps, holes, and your view is obstructed.

The same report noted that an OSU survey of 564 farmers found these 564 owned 856 tractors, and only 8.9 percent were equipped with ROPS.

It is difficult to determine the percentage of tractors that are equipped with ROPS. The following studies provide some estimates.

Based on a survey of 350 South Dakota farmers, Pelton (1990) estimated that 54% of South Dakota’s tractors were not equipped with ROPS. He also concluded that incentives would need to be provided for ROPS to be adopted on the older tractors, since 75% of the farmers responded they were not willing to purchase a ROPS at cost.

A study of 473 Iowa grain farmers (Ogilvie, 1990) indicated that 93% had at least one tractor that was not equipped with a ROPS. These tractors were indicated as being those involved in doing general chores and field work.
Purschwitz et al. (1991) conducted on-farm equipment inspections of 36 Wisconsin dairy farms. Of the 156 tractors inspected, 103 (66%) were not equipped with ROPS. They also divided this into age categories of tractors less than 20 years old and those greater than 20 years. Of the tractors greater than 20 years old, only 4 of the 69 were equipped with ROPS. The remaining 94.2% of tractors older than 20 were not equipped with ROPS. Fifty-six percent of the tractors newer than 20 years were equipped with ROPS.

**Retrofitting of ROPS**

The controversial engineering issue is how to get ROPS installed on the older tractors that farmers continue to use.

The literature indicates that a ROPS used in conjunction with a seatbelt does indeed significantly reduce tractor-related fatalities.

ROPS are available for tractors manufactured after 1969. In 1990 the National Farm Medicine Center in Marshfield, Wisconsin, released a directory (Purschwitz and Dupuis, 1990) with cost and accessibility information for ROPS that are available for specific tractor models. This directory was distributed nationally to county extension offices. At the present time, it is also being requested by implement dealers. Sample pages of the directory are contained in Appendix B.

In the foreword to this directory, Schnieder, an Extension Safety Specialist who has investigated tractor related accidents in Nebraska for 25 years reiterates the importance of ROPS. He states (Purschwitz and Dupuis, 1990:i):

Over my many years of safety work I have seen the development of all sorts of electronic devices to warn the operator of an impending overturn, but nothing no matter how sophisticated, does the job of protecting the farmer as well as a properly designed ROPS and seat belt.
Schnieder also estimates that of the 4.5 million tractors used in the U.S., only 1.3 million are equipped with ROPS.

A challenge to engineers is developing technological solutions that can be applied towards making the older equipment safer, since it is a fact that this equipment will be used for an estimated 25-30 years. The Iowa Census of Agriculture for 1987 indicated that 94% of the tractor population used in Iowa was manufactured prior to 1983.

Initial results from a tractor inventory survey of approximately 200 northeast Iowa farmers indicates reasons for not using ROPS (Lehtola, 1992). Reasons given, in order from highest to lowest were:

1. ROPS would interfere with the tractor's usage
2. Cost
3. They did not know where to obtain a ROPS or have it installed
4. They needed more information about ROPS and what is available.

Initial results also estimated that approximately 28-33% of the tractors were equipped with ROPS.

Adjustable ROPS

A frequent response farmers have as to why they do not use ROPS is that it will interfere with the use of the tractor. They may use a utility type tractor in buildings and the contention is that the ROPS gets in the way. Currently research is being done in Morgantown, West Virginia, as a part of a National Institute for Occupational Safety and Health (NIOSH) study. This study is considering the human factor requirements and feasibility of adjustable ROPS. These are designed to fold down so they can be lowered when doing work where they otherwise would interfere.
Adjustable ROPS are presently available on some tractor models, especially smaller, utility type tractors.

The South Dakota study (Pelton, 1990) found that less than 6% of the farmers actually felt the presence of the ROPS interfered with the tractor’s usage. However, when asking farmers why they don’t use ROPS, the typical response is that it would interfere with the tractor’s use.

Additionally in a conversation with Iowa implement dealer Mark Baumler (1992) it was indicated that a very small percentage (less than 5%) remove an existing ROPS because it actually does interfere with the tractor’s usage.

Summary

This literature review has provided background on the scope of the agricultural safety problem as it applies to the entire farm scene and as it specifically applies to tractors. General farm safety issues and interventions were discussed since these principles are necessary for a project that focuses on tractor related safety issues and interventions.

Based on the review of the literature, the following conclusions were made:

1. Machines are the agent accounting for the highest number of agriculturally related fatalities and injuries.

2. Tractors are the machine involved in the highest number of agriculturally related fatalities.

3. Tractor overturns account for the highest number of tractor related accidents.

4. Use of the rollover protective structure (ROPS) does substantially reduce the number of tractor related fatalities due to overturn.

5. No substantial tractor accident studies have been done since the 1970’s.
6. There was little or no information that gave specific details on the tractor related accidents, i.e., type of tractor involved and accident descriptions.

Based on the lack of specific information in the literature, it was concluded that a study for the purpose of identifying factors in tractor related accidents in order to recommend mitigation strategies, was needed. Tractors have been recognized for years as the leading agent in agricultural fatalities; however, very little research for the purpose of developing intervention strategies has been conducted. It is intended that this study will fill that gap.

It is apparent from the many examples cited that safer farming requires contributions from many different disciplines. These include farmers, engineers, health professionals, community businesses, educators, universities, and industry. No single entity can accomplish the task, and yet the task can not be accomplished with the absence of any one of these key disciplines.
CHAPTER III.

METHODS

Purpose

This study was conducted for the purpose of identifying specific factors involved in tractor-related accidents in order to develop strategies for reducing tractor-related deaths and injuries.

This chapter describes 1) how the tractor-related accident data source was obtained, and 2) the procedures used for obtaining detailed information about each of these accidents.

Objectives

The objectives identified for this study were:

1. To identify specific factors involved with tractor related accidents in Iowa during a three year period.
2. To analyze the effectiveness of possible intervention strategies.
3. To recommend effective intervention strategies.

Study Design

The investigation of tractor-related accidents was conducted as a descriptive study, reporting events that have already happened and over which the researcher had no control.

In order to identify specific factors involved in Iowa's tractor related accidents, detailed information had to be obtained from each individual accident. Thus tractor accidents needed to be identified; names of victims obtained; and the accident information required needed to be identified.
To identify the factors necessary to meet the project's objectives it was determined that additional information needed included: location of the accident; if the victim was the tractor operator; tractor make, model, type, and age; tractor use at the time; if overturn, type and degrees of roll, and ROPS and seatbelt usage.

The procedure used to obtain this information is described in further detail in the ensuing sections of this chapter.

To implement the study, the following steps were done:

1. Names of tractor accident victims were obtained from the Extension Safety Specialist at Iowa State University.
2. An instrument for obtaining follow-up information was developed.
3. Follow-up information was obtained through a cooperative effort with the Iowa Department of Public Health.
4. Follow-up information was analyzed.
5. Based on the results, intervention strategies were recommended.

Data Source

Names of people that had been involved in tractor related accidents for the three years 1988, 1989, and 1990 were obtained from data collected initially by the office of the Extension Safety Specialist at Iowa State University. In 1988, that office began employing the services of a newsclipping service to collect information on agriculturally related accidents in Iowa. This was the first recent attempt in the state to continually monitor agricultural accidents as they occurred. The newsclipping service had access to all of Iowa's newspapers, from which they clipped articles relating to farm safety as well as reports of farm accidents. The clippings were
sent to the Extension Safety Specialist on a periodic basis. The specialist categorized accidents and prepared a summary of the county, date, victim's age, and a brief description for each accident that had been reported in the newspapers. These reports included fatalities, injuries, and some accidents that involved no injuries. The same method of agricultural accident data collection was used in 1989 and 1990 as well. No attempt was made by the Safety Specialist to find out additional information that was not noted in the news reports. Additional information was gathered by this author as a part of the research study.

The data base used for this study consisted of those accidents that had been compiled from the 1988, 1989, and 1990 Extension summary reports that involved agricultural tractors. Since it was impossible to ascertain from newsclippings if a power take-off (PTO) related accident involved the tractor portion of the PTO or the machine portion of the PTO, the PTO category was not included in this study. The PTO incidents for these three years involved a relatively small portion, 6.5%, of the total tractor and PTO incidents (12 out of 185 incidents). Six of the PTO incidents were fatal.

The Extension report placed skidloaders and tracked tractors in other categories; however, they were included in this study since they are used on a daily basis on Iowa’s farms. Garden size tractors were not included.

This study included only the 173 agricultural tractor related accidents that were reported, in newspapers, to have happened in Iowa during the three years 1988-90.
Procedures

The news report for each of the 173 incidents was reviewed. Names of the operator and/or those involved were recorded, along with a summary of accident location, age of victim, and other details as may have been included in the newsclipping report or photograph.

A questionnaire follow-up form was prepared in order to obtain the previously described detailed information about each incident. The follow-up questionnaire was derived by modifying the tractor portion of the standardized Farm Accident Survey form developed by the National Safety Council (NSC) in 1968 and revised in 1979. This form was developed and revised by the NSC as the result of the experiences gained from conducting farm accident surveys in eight states (National Safety Council, 1979). The instrument developed for this Iowa tractor study is contained in Appendix C. This form is similar to that used by Williams (1983) in his 1981 Agricultural Accident Survey of Iowa’s Farm People.

Questionnaires were prepared for distribution to a representative from each of the 173 incidents. This could be the tractor operator, surviving family member, or local sheriff’s office. The 173 incidents involved a total of 218 people; however, since the purpose of the study involved tractor and operator characteristics, every person involved was not included in the follow-up.

The Iowa Department of Public Health (IDPH) had begun a project in 1990 for recording agricultural injuries and fatalities in Iowa. This project, Sentinel Project Researching Agricultural Injury Notification Systems (SPRAINS) obtains reports of agricultural injuries that have been treated in Iowa’s hospitals and clinics. The project is funded for three years by the Centers for Disease Control (CDC) as a pilot study for agricultural accident surveillance and data collection.
A portion of the SPRAINS project includes follow-up, using adapted NSC Farm Accident Survey Forms, on the reported injuries and fatalities.

During the summer of 1990, tractor follow-up forms were distributed to the public health nurses in the counties where tractor accidents occurred. The county nurses were to obtain the necessary information and return it to the IDPH. Follow-up of the 1990 fatal incidents was done by the SPRAINS investigator at the state IDPH office, often through the law enforcement offices. The county nurses obtained the follow-up information either by phone or personal interviews, and in some cases by mail. Since data collection was conducted through the Health Department, nurses were offered the flexibility of obtaining the information however they felt best.

The data were analyzed by collating the information from the returned questionnaires. Some additional information was available from the news reports and as many items as possible were entered into the analysis. The total response rate was 49% (84) while 65% (56) of the fatal incidents responded.

When a report was returned, the name of the person(s) involved was removed and further analysis was done by means of a code number only. The code number did represent the county and the incident number. Analysis was done on a regional rather than county basis in order to protect the privacy of the people involved.

Information obtained was used for the purpose of proposing intervention strategies.

Assumptions and Limitations

Locations of the reported accidents were compared with the locations of Iowa's newspapers. The observation made from this comparison was that location did not appear to be
a factor in the number of accidents that had been reported. Counties with several papers may have had no reported tractor related accidents, while those with one or zero papers may have had several reported incidents. Therefore, the assumption made for this study was that location of newspaper was not a factor in the number of tractor accidents reported.

A comparison of the 1990 newsclipping reports with the SPRAINS data revealed that SPRAINS did not have any additional tractor-related fatalities that were not a part of the newspaper list. There were discrepancies with injuries in that SPRAINS reported more injuries than were reported in the newspapers. Tractor-related injuries are less likely to be reported in the newspaper, than are fatalities. The number of injuries reported in newspapers is greatly understated.

Initially the IDPH felt the county public health nurse network in each of the counties would be the channel to use for questionnaire dissemination and data collection. The IDPH wanted to test the feasibility of using the county health nurse network for obtaining SPRAINS follow-up information. Based on the results of that experience the IDPH SPRAINS personnel concluded that utilizing the county public health nurse network for follow-up of agricultural accidents was not an effective or viable method for obtaining the desired information. Many of the nurses felt they were already overloaded with work and could not take on additional projects. Some felt that follow-up of fatalities was not something that should be done. Others did not have any interest in agriculture and failed to see the purpose or recognize the significance of investigating agricultural accidents.

Additional limitations included obtaining accurate responses from victims or surviving family members for an incident that may have occurred two years ago. In some cases, people had moved and were not able to be located.
Summary

Overall the above procedures and methods were felt to be satisfactory in obtaining necessary data towards determining tractor accident situations and proposing intervention strategies. The instrument that was developed to be used as the questionnaire was effective in obtaining the information required. A question regarding the cost of the accident did not receive appropriate responses and therefore this item was deleted from any analysis. It was felt that an estimation of the visible and hidden costs (total cost) could not be obtained from the information that was returned.

The county health nurse network also was not the most effective vehicle for implementing the questionnaires. Since this study was completed, the agricultural injury surveillance project conducted through the Iowa Department of Public Health has four nurses throughout the state whose role is to obtain follow-up information on agricultural accidents as they occur. This method is proving effective.

Results were used to develop an intervention plan, which is described in Chapter V of this study.
CHAPTER IV.

RESULTS AND DISCUSSION

This study was conducted for the purpose of identifying specific factors involved in tractor-related accidents in order to develop intervention strategies. The objectives of the study were:

1. To identify specific factors involved with tractor related accidents in Iowa during a three year period.

2. To analyze the effectiveness of possible intervention strategies.

3. To recommend effective intervention strategies.

This chapter identifies the specific factors associated with tractor related accidents in Iowa over the three years of data collection. Intervention strategies are analyzed and recommended in Chapter V.

Results of the study indicated that two-hundred-eighteen people were involved in the 173 tractor-related incidents reported in Iowa newspapers during the three years of 1988-90. These 218 persons included tractor operators, motor vehicle occupants, riders on the tractor, and others standing or working near the tractor (by-standers).

Eighty-seven (40%) of the 218 people were fatalities. Of the 173 incidents, eighty-six (50%) involved a fatality. One incident accounted for two fatalities. The fatalities are summarized in Appendix D.

A follow-up questionnaire was prepared for each of the 173 incidents. Questionnaires were prepared for distribution to the tractor operator involved in the incident, to surviving family members, or to law enforcement officials familiar with the event. The questionnaires were sent to the public health nurse in each of the counties involved by the Iowa Department of Public Health (IDPH) in order that they would obtain the necessary follow-up information.
Eighty-four (49%) of the questionnaires were completed and returned. Fifty-six (65%) of the 86 questionnaires for fatal incidents were completed. Reasons for non-completion included:

1. The public health nurse not having the time or interest to perform the task.
2. The occasional refusal of accident victims or surviving family members to participate. However, people were cooperative and willing to provide information for fatal incidents. Many surviving family members found this as a way to help others.
3. Questionnaires for the incidents that had occurred early in the study were less likely to be completed than those that had occurred more recently. People involved tended to have forgotten details or didn’t want to be reminded of the incident. In some instances, the victims or survivors had moved and could not be located.
4. The case was in litigation.

The data set was completed as well as possible with the information available. For example, although a follow-up questionnaire may not have been returned, the newsclipping may have included a photo from which key items (e.g., type of tractor, presence of ROPS, and type of accident) could be determined.

The data analysis is summarized in two sections. Part I identifies factors involved in tractor related accidents in Iowa for the three years of 1988, 1989, and 1990. Part II presents examples of the types of accidents that occurred with the highest frequencies over the 3-year period.

Since accidents are relatively rare events and affect a small proportion of the population within the time period studied, the sample size for analysis and deriving conclusions is limited. However, a summary of causative factors and high frequency events does provide an expanded
knowledge and awareness of tractor related accidents in Iowa which can be used to develop intervention strategies.

This study provides valuable information on the frequencies of types of tractor accidents that occurred and are still prevalent.

Part I. Identification of Factors Involved

Since the accidents studied were identified from newspaper reports, it was recognized that not all tractor related accidents were reported. A comparison with the IDPH farm accident data for 1990 supports the assumption that all the fatalities were reported in the newspapers. However, if someone overturned a tractor in the field and was not injured, that accident most likely was not reported. There was no way to estimate the proportion of non-fatal accidents actually reported. Very likely the number of non-fatal and non-injurious accidents reported to have occurred in fields or farmyards greatly understates the number that actually occurred. Roadway accidents would be expected to be reported more frequently than those occurring in the field, since they often involved the services of law enforcement officials and rescue personnel.

Items are summarized for both the total number of reported incidents and the number of fatalities. Even though all non-fatal accidents were not reported, showing the number reported is of value since it does portray events that have happened.

Accident and fatality rates were analyzed for each of Iowa's nine Crop Reporting Districts (CRD). Figure 1 shows the CRD's and accident and fatality numbers.

It was necessary to group together and describe the accidents at the CRD level rather than county level in order to maintain the confidentiality of individuals. Also counties within a CRD
tend to have similar topographical conditions and farming practices; thus there was logic in grouping accident data according to the CRD district.

To identify factors involved in tractor related accidents, the following research questions were considered:

1. Were there differences in numbers of tractor-related accidents between years?

2. Were there differences in tractor-related accident numbers and fatality rates between regions of the state?
3. Were there differences between regions for tractor-related fatality rates based on tractor population and hours of tractor use.

4. Were there differences in tractor-related accident numbers occurring on roads and accidents occurring off the road?

5. Were there differences in tractor-related accident occurrences between months of the year?

6. Were there differences in tractor-related accident occurrences between days of the week?

7. Were there differences in tractor-related accident occurrences between hours of the day?

8. Were there differences in tractor-related accident occurrences between males and females?

9. Were there differences in tractor-related accident occurrences between operator age groups?

10. Were there differences in tractor-related accident occurrences between age categories of tractors?

11. Were there differences in tractor-related accident occurrences between types of tractors?

Table 5 lists the number of fatalities by year for each CRD, and Table 6 lists the fatality rates based on deaths/1000,000 tractors.

Table 5. Iowa tractor-related fatalities for 1988-90 for each crop reporting district

<table>
<thead>
<tr>
<th></th>
<th>NW</th>
<th>NC</th>
<th>NE</th>
<th>WC</th>
<th>C</th>
<th>EC</th>
<th>SW</th>
<th>SC</th>
<th>SE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>1989</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>1990</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>3-year total</td>
<td>11</td>
<td>8</td>
<td>21</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>87</td>
</tr>
</tbody>
</table>
The total number of deaths statewide each year was nearly constant, but there was considerable year to year variation within crop reporting districts (Table 5). The same is true for fatality rates (Table 6). Analyses of variance showed no significant differences for numbers of fatalities or for fatality rates between years or crop reporting districts. While there were 21 deaths in the Northeast district and only three in the Central district over the three-year period, the data do not support a conclusion that tractor-related deaths are more likely to occur in one crop reporting district than in any other.

Discussion of the research questions posed is based on the data observed. While the data suggest trends and relationships, the small number of occurrences in given categories, and the year to year variations were such that statistically significant differences were not found.

**Fatality rate calculation**

According to the 1987 Census of Agriculture, the tractor population of Iowa was 302,392. This number was assumed to be the Iowa tractor population for each of the three years of this study. The fatality rate given was on a per year basis.
Tractor accidents by years

Tractor accident numbers and rates by year are shown in Table 7. Figure 2 is the graphical presentation of this data.

Table 7. Iowa tractor-related accidents by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Reported Incidents</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Number of Non-injuries</th>
<th>Total People Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Rate*</td>
<td>Number</td>
<td>Rate*</td>
<td>Number</td>
</tr>
<tr>
<td>1988</td>
<td>67</td>
<td>22.2</td>
<td>31</td>
<td>10.2</td>
<td>12</td>
</tr>
<tr>
<td>1989</td>
<td>55</td>
<td>18.2</td>
<td>26</td>
<td>9.6</td>
<td>7</td>
</tr>
<tr>
<td>1990</td>
<td>51</td>
<td>16.9</td>
<td>30</td>
<td>9.9</td>
<td>7</td>
</tr>
<tr>
<td>Totals</td>
<td>173</td>
<td>19.1</td>
<td>87</td>
<td>9.6</td>
<td>26</td>
</tr>
</tbody>
</table>

*Rate based on 100,000 tractors per year

Figure 2. Tractor-related accidents by year of occurrence Iowa 1988-90
Two hundred eighteen people were involved in the 173 incidents reported. These included tractor operators, vehicle occupants, tractor riders, and bystanders. Of the 173 incidents, eighty-six (50%) involved a fatality. One incident resulted in two fatalities.

Observation indicates the numbers of tractor-related accidents and fatalities was the same for each of the three years.

**Tractor accidents by crop reporting district**

The tractor population per district was obtained from the populations provided for counties in the 1987 Census of Agriculture. The average hours of annual use per tractor in each district was estimated by Duffy (1991:32) from a statewide survey of 1,181 randomly selected Iowa farms. The survey was conducted for the purpose of providing a better understanding of crop production practices and energy use in Iowa.

Table 8 shows the tractor population and average hours of use per tractor for each of the CRD's. These numbers were used in determining fatality rates based on tractor usage.

### Table 8. Tractor population and average hours of use per tractor

<table>
<thead>
<tr>
<th>Crop Reporting District</th>
<th>Number of Tractors</th>
<th>Hrs. Use/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest (NW)</td>
<td>39,683</td>
<td>247</td>
</tr>
<tr>
<td>North Central (NC)</td>
<td>34,785</td>
<td>252</td>
</tr>
<tr>
<td>Northeast (NE)</td>
<td>45,258</td>
<td>295</td>
</tr>
<tr>
<td>West Central (WC)</td>
<td>36,772</td>
<td>256</td>
</tr>
<tr>
<td>Central (C)</td>
<td>39,429</td>
<td>218</td>
</tr>
<tr>
<td>East Central (EC)</td>
<td>37,036</td>
<td>237</td>
</tr>
<tr>
<td>Southwest (SW)</td>
<td>22,451</td>
<td>291</td>
</tr>
<tr>
<td>South Central (SC)</td>
<td>20,549</td>
<td>250</td>
</tr>
<tr>
<td>Southeast (SE)</td>
<td>26,429</td>
<td>252</td>
</tr>
<tr>
<td>Iowa</td>
<td>302,429</td>
<td>254</td>
</tr>
</tbody>
</table>

*1987 Census of Agriculture  

b Duffy, (1991:32)
Table 9 presents and compares the tractor-related accident summary based on tractor population and hours of tractor use for regions of the state. Figures 3 and 4 present this information graphically.

Observation indicates the NE district had the highest fatality rate, followed closely by SC, SE, and EC. The Central district had the lowest fatality rate. Even though statistical testing did not establish significant differences, it appears there are portions of the state that do have a high tractor-related fatality incidence. Factors that may account for the higher incidence in the NE when compared to Central include: hilly topography and intensive livestock operations (dairy) that require daily tractor usage both winter and summer.

Table 9. Tractor-related accident summary by crop reporting district 1988-90

<table>
<thead>
<tr>
<th>CRD District</th>
<th>Incidents</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>% of Total</td>
</tr>
<tr>
<td></td>
<td>Tractors</td>
<td>per 100,000 Tractors</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>100.0</td>
</tr>
<tr>
<td>Tractors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours</td>
<td></td>
<td>19.1</td>
</tr>
<tr>
<td>Northwest 19</td>
<td>11.0</td>
<td>16.0</td>
</tr>
<tr>
<td>North Central 14</td>
<td>8.1</td>
<td>13.4</td>
</tr>
<tr>
<td>Northeast 38</td>
<td>22.0</td>
<td>28.0</td>
</tr>
<tr>
<td>West Central 19</td>
<td>11.0</td>
<td>17.2</td>
</tr>
<tr>
<td>Central 14</td>
<td>8.1</td>
<td>11.8</td>
</tr>
<tr>
<td>East Central 24</td>
<td>13.8</td>
<td>21.6</td>
</tr>
<tr>
<td>Southwest 8</td>
<td>4.6</td>
<td>11.9</td>
</tr>
<tr>
<td>South Central 18</td>
<td>10.4</td>
<td>29.2</td>
</tr>
<tr>
<td>Southeast 19</td>
<td>11.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Statewide 173</td>
<td>100.0</td>
<td>19.1</td>
</tr>
</tbody>
</table>
Figure 3. Tractor-related fatality rate (per 100,000 tractors) by crop reporting district Iowa 1988-1990
Figure 4. Tractor-related fatality rate (per 100,000 hours of tractor use) by crop reporting district Iowa 1988-1990
Differences between road and field/farmyard

Accident locations are compared in Table 10. Road and non-road incidents and fatalities were evaluated regionally and statewide.

Table 10. Location of occurrence: comparison of field/farmyard and public roadways

<table>
<thead>
<tr>
<th>CRD District</th>
<th>Incidents (N=173)</th>
<th>Fatalities (N=87)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field/Yard</td>
<td>Road</td>
</tr>
<tr>
<td>Northwest</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>North Central</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Northeast</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>West Central</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Central</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>East Central</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Southwest</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>South Central</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Southeast</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Statewide</td>
<td>95</td>
<td>78</td>
</tr>
</tbody>
</table>

Statewide for the total number of incidents reported (fatal and non-fatal) there was no observed difference between road and non-road as the location of occurrence. Fifty-five percent of the incidents occurred in the field/farmyard, while forty-five percent happened on a public roadway.

The number of fatalities occurring off the road were higher than the number of roadway fatalities. There were 59 non-road fatalities which accounted for 67.8% of the 87 reported fatalities. Tractors are used a greater percentage of the time in field/farmyard work, than they are on the road.
Analysis by month

Table 11 indicates the summary of tractor related accidents by month, and shows that June had the highest number of incidents; while August had the highest number of fatalities. Figure 5 provides a graphical presentation of the relationship between months.

Table 11. Tractor-related accidents by month

<table>
<thead>
<tr>
<th>Month</th>
<th>Incidents (N=173)</th>
<th></th>
<th>Fatal Incidents (N=86)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>% of Total</td>
<td>Number</td>
<td>% of Fatal Incidents</td>
</tr>
<tr>
<td>Jan</td>
<td>10</td>
<td>5.8</td>
<td>5</td>
<td>5.8</td>
</tr>
<tr>
<td>Feb</td>
<td>9</td>
<td>5.2</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>Mar</td>
<td>7</td>
<td>4.0</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>Apr</td>
<td>11</td>
<td>6.4</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>May</td>
<td>17</td>
<td>9.8</td>
<td>12</td>
<td>14.0</td>
</tr>
<tr>
<td>Jun</td>
<td>23</td>
<td>13.3</td>
<td>9</td>
<td>10.5</td>
</tr>
<tr>
<td>Jul</td>
<td>18</td>
<td>10.4</td>
<td>12</td>
<td>14.0</td>
</tr>
<tr>
<td>Aug</td>
<td>20</td>
<td>11.6</td>
<td>13</td>
<td>15.1</td>
</tr>
<tr>
<td>Sep</td>
<td>20</td>
<td>11.6</td>
<td>8</td>
<td>9.3</td>
</tr>
<tr>
<td>Oct</td>
<td>21</td>
<td>12.1</td>
<td>8</td>
<td>9.3</td>
</tr>
<tr>
<td>Nov</td>
<td>7</td>
<td>4.0</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>Dec</td>
<td>10</td>
<td>5.8</td>
<td>4</td>
<td>4.6</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>100.0</td>
<td>86</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Note: 86 Fatal incidents, 1 incident had 2 fatalities

May, June, July, and August were months when a large number of the fatalities occurred. Iowa field operations during this time may include planting, spraying, cultivating, mowing, haying, and routine chore operations.
Figure 5. Tractor-related accidents by month of occurrence Iowa 1988-1990

Day of the week

Table 12 shows that Monday accounted for the highest number of accidents and fatalities with 21% for each. This has been observed in previous farm accident data as well. Knapp (1964) noted this in the accidents monitored through The University of Iowa in 1964. 1991 IDPH (Iowa Department of Public Health, 1992) data showed that 33% of the tractor related fatalities occurred on a Monday. However, this information is presented as an interesting observation, since the data do not show a statistically significant difference between days of the week.
Table 12. Tractor-related accidents by day of the week

<table>
<thead>
<tr>
<th>Day</th>
<th>Reported Incidents</th>
<th>Fatal Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>% of Total</td>
</tr>
<tr>
<td>Sunday</td>
<td>21</td>
<td>12.1</td>
</tr>
<tr>
<td>Monday</td>
<td>37</td>
<td>21.4</td>
</tr>
<tr>
<td>Tuesday</td>
<td>21</td>
<td>12.1</td>
</tr>
<tr>
<td>Wednesday</td>
<td>27</td>
<td>15.6</td>
</tr>
<tr>
<td>Thursday</td>
<td>22</td>
<td>12.7</td>
</tr>
<tr>
<td>Friday</td>
<td>21</td>
<td>12.1</td>
</tr>
<tr>
<td>Saturday</td>
<td>24</td>
<td>13.9</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Time of day

Figure 6 indicates that tractor related accidents increase over the day with a morning high at 11 am and with the highest incidence for the day occurring at 4 pm. It needs to be stated that the accidents decline over the lunch hour. An hour is defined as the range from the beginning of the hour to the end of the hour, i.e., 11 am includes those accidents happening between 11:00 and 11:59.

This pattern has been found throughout the literature in agricultural safety studies and accident data collection (Hanford et al., 1982; Massie, 1979). Factors assumed to contribute to this include: fatigue, hunger, the numbing of the senses due to machine vibrations and noise, and boredom induced by monotonous, repetitive operations. The afternoon peak also may add the youth population coming home from school, and those people employed off the farm during
the day. Livestock feeding chores are done at this time of the day. In the winter season, daylight diminishes at this time. Data were not available to definitely establish those linkages. The addition of other populations to the farm work-force, especially off-farm employed, may be more prevalent in other parts of the United States where the proportion of small, part-time farmers is greater.

Figure 6. Tractor-related accidents by time of day of occurrence Iowa 1988-1990
Gender

Table 13 indicates that males were involved in the greatest proportion of tractor accidents. Of the operators, only 2 were females. Twenty females were involved as others, these included motor vehicle occupants, tractor riders, and bystanders. Five (5.7%) of the eighty-seven fatalities were females. Only one (1.1%) of these was operating the tractor.

Table 13. Victims of tractor-related accidents by gender (N=218)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Operators</th>
<th>Others</th>
<th>Unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Victims</td>
<td>Fatalities</td>
<td>Number of Victims</td>
</tr>
<tr>
<td>Male</td>
<td>155</td>
<td>72</td>
<td>39</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>157</td>
<td>73</td>
<td>59</td>
</tr>
</tbody>
</table>

Speculations about reasons for these results include: 1) females are more careful 2) females on the farm do the less hazardous activities or operate the safer equipment, or 3) females have lower exposure rates as tractor operators. While data aren't available, observation indicates that females do indeed have considerably lower exposure as tractor operators. The National Safety Council (Hanford et al., 1982) estimated that males accounted for 77% of the total man-hours of work reported on farms. This was for all agricultural activities and not just tractor operation.

Age

The age categories used for the purposes of this study were similar to those used by the National Safety Council for its Standardized Farm Accident Survey form (Williams, 1983). They divided ages into the following groups: under 5 were not included; 5-14; 15-24; 25-44; 45-64; and 65 and over.
For purposes of this study, the following age groups were used: 0-4, 5-12, 13-18, 19-25, 26-40, 41-60, and over 60.

The rationale for the selection of the above categories was based on the following assumptions:

0-4: People in this age group are not operating tractors, but they are involved as bystanders or passengers. A Wisconsin study (Tevis and Finck, 1989) indicated that accidents for farm children peaked at age 4.

5-12: This age group is in the stage of beginning to operate tractors and be exposed to more farm tasks. It was reported that 65% of farm boys operate a tractor by themselves at 10-12 years and almost 30% are tractor drivers at 7-9 years (Tevis and Finck, 1989).

13-18: This group would perhaps be more mature, physically adept, and skillful in handling a tractor than the previous age category. It was felt there is a difference between a five year old and a teen-ager in their physical and mental ability for operating a tractor. This group would involve junior high and high school students who would not be on the farm full-time.

19-25: This group would be finished with school, and may now be on the farm full-time and thus have higher exposure rates. It was also felt that a 19 year old should not be grouped with a 13 year old.

26-40 and 41-60: These two groups together consist of those that are the main farm workers with the most exposure to farm work. Williams (1983:42) found that:

persons between 25-64 were involved in significantly more accidents than expected. This can be explained by the amount of exposure for persons in the two age groups [25-44 and 45-64] relative to the exposures of persons in other age groups.
Over 60: This group was categorized due to older operators beginning to have diminished physical capabilities and as farmers progressed in years, many also begin limiting their exposure rate.

During the three years studied, the youngest tractor operator involved in an accident was an 11 year old male who sustained a minor injury. In this case the tractor stalled as he was driving the tractor uphill on a gravel road. As it rolled backwards, the right rear tire entered the ditch and the tractor overturned. The boy was pinned beneath the tractor but sustained only minor injuries. This situation involved lack of experience and training (knowledge of what to do in that situation), as well as perhaps not sufficient strength to handle brakes, clutch, and restart the tractor all simultaneously. Also if the tractor had power brakes and power steering, these would become non-functional when the tractor stalled.

The youngest operator fatality was a 14 year old male who was operating a tractor on a gravel road. He was driving too fast for conditions, ran the stop sign, and made a sharp right turn. The tractor slid into the ditch and overturned, pinning the victim. This was due to lack of experience, thus operating the tractor improperly for existing conditions.

The youngest non-operator fatality involved a three year old female who fell out of the tractor cab when the door opened during a field operation. The child was run over by the rear wheel of the tractor. Her father was operating the tractor.

The oldest operator fatality was 91. He apparently fell from the tractor and was run over. The tractor was a narrow front end model, older than 10 years. It is speculated that he may have been jostled about due to rough terrain. Older tractor seats are easy to slide off of, thus he may not have had the strength or stamina to hang on.
Figures 7 and 8 show the percentage of fatalities for age groups. Figure 7 includes tractor operators, vehicle occupants, tractor riders, and bystanders. The 20 year interval of the 41-60 age category accounted for 32% of the fatalities. Thirty-seven percent of the fatalities were incurred in the age group of greater than 60 years.

N = 87

Figure 7. Percentage tractor-related fatalities by victim's age (years) (includes operators and others) Iowa 1988-1990
Figure 8. Percentage tractor-related fatalities for tractor operators by victim's age (years)
Iowa 1988-1990

Figure 8 shows ages for operator fatalities. Of the 87 fatalities, 73 (84%) were the tractor operator. The 41-60 year age group accounted for 33% of the operator fatalities while the group aged 60 and older accounted for 40% of the total operator fatalities. Since the age categories were based on skill and exposure criteria, the number of years in each interval are not equal. A summary of number of fatalities per year of age is provided in Table 14. This suggests that operators over 40 years of age are at increased risk. This may be due to more hours of exposure or more operators in that age group. It could also be due to slower reactions in hazardous situations, particularly by those over 60.
Table 14. Number of fatalities per year of age Iowa 1988-1990

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Operators Number</th>
<th>Operators Fatalities per year of age</th>
<th>All Number</th>
<th>All Fatalities per year of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.25</td>
</tr>
<tr>
<td>5-12</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0.38</td>
</tr>
<tr>
<td>13-18</td>
<td>3</td>
<td>0.50</td>
<td>4</td>
<td>0.67</td>
</tr>
<tr>
<td>19-25</td>
<td>5</td>
<td>0.71</td>
<td>6</td>
<td>0.86</td>
</tr>
<tr>
<td>26-40</td>
<td>11</td>
<td>0.73</td>
<td>11</td>
<td>0.73</td>
</tr>
<tr>
<td>41-60</td>
<td>24</td>
<td>1.20</td>
<td>28</td>
<td>1.40</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>29</td>
<td>1.20</td>
<td>32</td>
<td>1.30</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Note: for > 60, 25 years was used

**Age of Tractor**

Figure 9 indicates that at least 44% of the tractors involved in a fatal accident were over 10 years old. For 42% of the tractors, tractor age data were not available. The assumption was that many of those not identified would be in the older than 10 years age group. This was based on conversations with implement dealers, IDPH personnel, and manufacturers whose observations indicate that it is the older tractors that are involved in the fatalities.

The fatality involving the tractor that was less than 1 year old involved the victim being pinned between the tractor and the equipment while hitching.

**Tractor type**

Figure 10 shows the percentage of fatalities by tractor type. Forty-two percent of the tractors were not identified by type. At least twenty-eight percent of the tractors involved in fatal accidents were the narrow front or tricycle type. Wide front type tractors accounted for fourteen percent of the fatalities. There are no data on the numbers of types of tractors in use, but drive-by observations of Iowa farms indicate the tricycle and wide-front types are those
Figure 9. Percentage of tractor-related fatalities by tractor age Iowa 1988-1990
used more frequently than the four wheel drive and front wheel assist types. Preliminary University of Iowa survey data indicates that 28% are narrow front (Lehtola, 1992). National Safety Council data (Hanford et al., 1982) indicate the narrow front comprises 26% of the tractor population on a nationwide basis.

Since the skidloader is commonly used on many livestock farms, it was included in this study. The skidloader accounted for the third highest tractor type involved in fatalities with 8%.

![Figure 10. Percentage tractor-related fatalities by tractor type Iowa 1988-1990](image-url)
Conclusions

Based on the results of this study, factors involved in tractor related accidents were identified. Due to a limited number of data points, conclusions made were based on observation. Statistical tests showed no significant differences. The following conclusions were made for the research questions investigated:

1. Numbers of tractor-related fatalities were nearly the same for each of the three years.
2. Statistically, there was no difference in fatality rates for regions of the state.
   Observation indicated the hillier areas of the state with more hours of tractor use had higher fatality rates.
3. Road and non-road locations were similar in proportions of incidence reported.
4. The summer months of May, June, July, and August had the highest number of incidents and fatalities. For Iowa, tractor use during these months involves mowing, haying, planting, cultivating, spraying, and routine chores.
5. It was observed that Monday had the highest number of reported incidents as well as fatalities. No speculations were provided.
6. The accidents peaked at 11:00 a.m. for the morning with 4:00 p.m. being the peak for the day. This may be primarily due to fatigue and physiological aspects of the operator.
7. Males were predominately involved as tractor operators. Female victims were a passenger on a tractor, occupant of a motor vehicle, or a by-stander.
8. The age category of 41-60 accounted for 32% of the total fatalities, and the group older than 60 years accounted for 37% of the fatalities. Children age 12 and younger were involved in 4.6% of the fatalities; all were extra riders on a tractor. Age categories for
tractor operators indicated that 41-60 accounted for 33% of the fatalities, while the over 60 age group involved 39% of the fatalities. There were no operator fatalities under age 14.

9. The tractors older than 10 years were involved in the greatest proportion of tractor-related accidents for those where the tractor age was identified.

10. The narrow front tractors were involved in the greatest proportion of tractor-related accidents for those where the tractor type was identified.

Part II. Examples of High Frequency Events

This portion of the data analysis and discussion consists of studying those events that occurred with high frequencies.

The following categories of tractor accident situations were analyzed and discussed: overturns, runovers, motor-vehicle collisions, and alcohol involvement.

Overturns

The National Safety Council’s (NSC) Accident Facts (1990) indicates that overturns accounted for 55% of all on-the-farm tractor fatalities reported. Agricultural accident reports, surveys, and studies repeatedly report that tractor overturns are the number one tractor-related accident.

The Iowa tractor fatality data for 1947-71 compiled by Wardle and Hull (1975) stated that 62% of the tractor accidents were due to overturns.

The numbers and rates of overturns in Iowa were determined for each of the three years studied. This information is summarized in Table 15. This summary reveals that during the
time period studied, 58.6% of the tractor fatalities (with a one year high of 73.1%) were due to overturns. This table also shows that Iowa had a higher rate than was reported nationally.

Overturns can be further divided into the three categories of side, rear, and forward. The side overturn is the most frequent with estimates of it accounting for 75% (Deere, 1987:151) to 85% (Baker et al., 1986:3) of all tractor overturns. Rear overturns are next, accounting for an estimated 15 to 25% of overturns; the forward overturn is relatively uncommon accounting for an estimated 1% of the tractor overturns. There were no identified forward overturns reported in Iowa during the years studied.

The Iowa data showed there were 90 overturns during the three years. Fifty-one (56.7%) of these were fatal.

Table 15. Iowa overturn fatalities by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
<th>% of Total Tractor Fatalities</th>
<th>Rate per 100,000 Tractors</th>
<th>National Rate of OT Fatalities per 100,000 Tractors*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>16</td>
<td>51.6</td>
<td>5.3</td>
<td>3.7</td>
</tr>
<tr>
<td>1989</td>
<td>19</td>
<td>73.1</td>
<td>6.3</td>
<td>4.0</td>
</tr>
<tr>
<td>1990</td>
<td>16</td>
<td>53.3</td>
<td>5.3</td>
<td>5.1</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>58.6</td>
<td>5.6</td>
<td>4.3</td>
</tr>
</tbody>
</table>

*National Safety Council(1991)

Figure 11, graphically shows the categories and numbers of overturn types that occurred. Side overturns accounted for 82.2% (74) of total overturns, rear overturns involved 7.8% (7), while 10% (9) were not identified. Of the side overturns 52.7% (39) were fatal; 71.4% (5) of the rear overturns were fatal, and 77.8% (7) of the undetermined were fatal.

Table 16 shows the location of occurrence of all overturns. Fifty-two (57.8%) of the overturns were identified as having occurred in a field or farmyard, while 38 (42.2%) occurred
on a public roadway. Of those occurring on a public roadway, a collision with a motor vehicle initiated the rollover in 10 (26.3%) of the instances. The remaining 28 (73.7%) drove off the road shoulder, entered the ditch and rolled. Those driving off the road shoulder and rolling over in the ditch accounted for 31.1% of the total overturns reported. Some of these were traveling along the road, while others were mowing the roadside ditches. These were either side overturns or not identified. Based on the dynamics involved and the amount of information that was available, it was estimated that of the non-identified roadway rollovers, the greatest proportion of them would have been side rollovers. One of them may possibly have been a front rollover.

![Figure 11. Tractor overturns by type of overturn. Iowa 1988-1990](image-url)
Table 16. Overturns and locations of occurrence (N=90)

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway</td>
<td>38</td>
<td>42.22</td>
</tr>
<tr>
<td>Into ditch/rolled</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Hit by vehicle/rolled</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Field or farmyard</td>
<td>52</td>
<td>57.78</td>
</tr>
</tbody>
</table>

A common example is the side overturn into a ditch. A probable cause is that as the tractor is being driven along the road, the right front wheel leaves the roadway and enters the ditch or a soft road shoulder; the operator's instinctive behavior is to steer the tractor back on to the road. This turning of the tractor away from its direction of travel will cause it to roll over on its side. Unexpected things occur that the tractor operator is not constantly on the lookout for, examples include run-off channels, animal holes, rocks or other debris, and in the event of mowing there may also be hidden obstacles.

Figures 12 and 13 show tractor overturns by tractor age and tractor type respectively.

Forty-one (45.6%) were known to be older than 10 years. Six (6.7%) were in the 6-10 years interval, and 1 (1.1%) was identified as being in the 2-5 years category. Forty-two (46.7%) were not identified.

Twenty-four (26.7%) were known to involve tricycle tractors, 17 (18.9%) were wide front, 2 (2.2%) were skidloaders, and there was 1 (1.1%) for each of the categories of front-wheel assist, and the crawler/track type. Fifty percent of the tractors involved in an overturn were not identified by type.
The conclusion is that older (> 10 years) tricycle type tractors are those more susceptible to overturn. These are also the tractors frequently used in the hazardous situations, e.g., chore type work on rough terrain.

1991 IDPH data indicated that 80% of the 1991 fatal overturn incidents involved a narrow front tractor.

Narrow front tractors began phasing out in the mid-60's to early 70's (Larsen, 1981) as farmers found they preferred the wide front tractors. Thus the assumption was made for this study that all narrow front tractors were older than 10 years.

Figure 12. Tractor overturns by tractor age. Iowa 1988-1990.
Figure 13. Tractor overturns by tractor type. Iowa 1988-1990.

Side overturn

Side overturns along roads and in fields can be precipitated by factors that are not always ascertainable by investigation or follow-up. For example, did the operator instinctively swerve to avoid an animal or an approaching vehicle? Did the operator bounce off the seat and instinctively grab the steering wheel as something to hang on to, thus moving it enough to turn the tractor down the slope?
Field overturns were incurred while carrying loads too high with the loader, (e.g., large round bales or dirt); spraying weeds along fence rows; herding cattle; driving along the edge of a dead furrow; hayfield operations; and maintenance mowing of untilled ground and terraces.

Of the fatalities due to overturns, a minimum of 5.9% (3) were known to be mowing at the time of the overturn. A minimum of 11 (12.2%) of the total (fatal and non-fatal) overturns were mowing at the time of the rollover; of these 6 (54.5%) were mowing ditches while 5 (45.5%) were mowing fields or terraces.

The degrees of roll depends on the speed of the tractor, steepness of the slope of the ditch or embankment, load being pulled, and whether or not the tractor was equipped with a Rollover Protective Structure (ROPS). In most cases, if equipped with a ROPS, the tractor will roll a maximum of 90 degrees (Deere and Co., 1987:157).

**Rear overturn**

The data indicated that 7.8% (7) of Iowa's tractor overturns were overturning to the rear, i.e., when the tractor pivots around the rear axle and flips over onto its top. Of the seven rear overturns, 5 (71.4%) were fatal. The rear overturn happens so quickly that the operator rarely has enough time to react and jump clear of the area. The rear overturn can take place in a total of 1.5 seconds with it taking only 0.75 seconds for the tractor to reach the "point of no return" (Deere and Co., 1987:147). Rear overturn causes include pulling a load uphill, being mired in mud, and attempting to pull a load that is hitched above the drawbar.

**Operator Protection**

Of the overturns in Iowa, there were no fatalities involving tractors equipped with a ROPS. The ROPS was discussed in Chapter II.
Table 17 summarizes the status of the tractor operators of those tractors equipped with ROPS. Of the 51 rollover fatalities, it is estimated that the presence of a ROPS would have prevented 49 of the deaths. Two of the fatalities involved a tractor passenger when the tractor rolled (the operator jumped clear in both cases).

Table 17. Status of operators of tractor with ROPS

<table>
<thead>
<tr>
<th>Type of Accident</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Non-injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seatbelt would have prevented</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(non-roll, fell off seat)</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinned between tractor and implement</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>while hitching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overturns</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Hit by train</td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

The system that has been developed to protect the operator includes the use of the ROPS in conjunction with the seatbelt. None of the operators involved in the 173 incidents reported they used the seatbelt.

Victim Run Over By Tractor

The victim being run over by the tractor involved 36 (20.8%) of the 173 incidents and accounted for 16 (18.4%) of the fatalities.

Based on the total number of incidents categories of run overs were:

1. The operator falls off the tractor (6.4%)
2. A passenger on the tractor falls off (4.6%)
3. A person attempts by-pass starting or starting the tractor from the ground (3.5%)
4. The tractor is parked and begins to roll while the operator is off the tractor (3.5%)
5. A by-stander or other person is run over (2.9%).
Operator falls off

This category included 11 (6.4%) incidents and involved 6 (6.9%) of the fatalities.

Schneider's comment about seats on older tractors often being in poor repair was noted previously in chapter II. The instances of the operator falling off the seat and being run over include situations of driving along rough field terrain on an older tractor and on a seat with no back or side supports. The operator bounces off and is run over. When a ROPS is installed on a tractor, and the seat belt is used, the operator is supported and held in place.

Narrow front tractors may bounce more and thus lead to an operator falling off the seat

Deere and Co. (1991:6) states:

operator comfort is reduced because some front wheels [of a narrow front] are rigidly attached to a short stub axle. The entire front end of the tractor bumps up and down when it hits a bump.

Newer seats and operator stations are greatly improved and do not present the problem that the older models do. However, in this three year study, there were two instances of operators falling out of these seats (a seatbelt would have held them in place); one of these operators was thrown from the cab and run over. The other remained in the cab of the tractor but impaled his head on the door latch when he was tossed off the seat.

Farmers have stated they do not use the seatbelt due to discomfort, frequent movement of the body while operating a tractor, and frequently getting on and off the tractor. Data from this study as well as farmer surveys indicate that farmers do not use the tractor seatbelt. A recommendation would be that different types of operator restraint systems be considered.
A passenger on the tractor falls off

This accounted for 8 (4.6%) of the 173 incidents and 5 (5.7%) of the 87 fatalities. This group involved 6 children, with an average age of 7.5 years. All the fatalities and 1 disabling injury involved children.

A survey of farmers conducted through the University of Iowa (Hawk, 1991) found that farmers thought it was safe to allow children to ride with on tractors with cabs, whereas they would not allow a child to ride on a tractor without a cab.

However, passengers do fall out of tractor cabs and are run over.

When a father runs over his own child with a tractor, the resultant guilt and consequences are long-lasting and usually devastating. Field and Tormoehlin (1982:12) studied agricultural accidents relating to farm children. They stated,

The loss or serious injury of a child can have considerable and often long lasting effects on any family--farm or non-farm. There are few losses, if any, that can result in a greater impact on a farm family or farm business. The trauma, emotional stress, and long term guilt often associated with serious accidents involving children have disintegrated many families and destroyed many farm businesses.

Tractor passengers present the additional hazard of the possibility of grabbing the steering wheel to hang on to in the event they begin to fall. This can result in an overturn.

Very little reference has been made to other hazards that tractor passengers are subject to. In addition to the potential for falling off and being run over, there is also the exposure to chemicals, dusts, noise and vibrations. These have been recognized as having detrimental effects on one's health (National Coalition for Agricultural Safety and Health, 1989).

One of the children injured as the result of falling off the tractor and being run over has been in a coma since the incident occurred (1.5 years). This situation was publicly described in
a talk by one of the family members of the victim. This family member stated (Thurman, 1991):

He [the seven year old] had seated himself on the fender of his daddy’s tractor when he went to mow hay. This was a common, every-day thing as his daddy, too, had grown up on the fender of a tractor. As farmers you know it is a little difficult to determine the terrain and rough places when they are hidden by waving hay at dusk. The tractor hit a bump, [the boy] fell off and was thrown in front of the tractor wheel which rolled up onto his head. He remains in a coma today, never having regained consciousness.

[A nurse commented to the father about an apparent grease stain on the boy’s hand], the father replied, "that isn’t grease that’s walnut stain." At the beginning of the mowing [the boy] had reached up into a low-hanging branch of a walnut tree and picked off a walnut. He and his daddy had talked about it and he had clutched it in his little hand throughout the evening. [The father] has told that story over and over and he never fails to smile and his eyes light up as he remembers that special sharing moment he had with his son.

In retrospect, of course, it is clear that avoiding the entire situation by not allowing the extra rider would have been the better choice and would have resulted in much more sharing time with the child over a lifetime.

A person attempts to by-pass start or start the tractor from the ground

The instances of by-pass starting or starting the tractor from the ground accounted for 6 (3.5%) of the total incidents and involved 2 (2.3%) of the fatalities.

In this circumstance the farmer starts the tractor from the ground either by by-pass starting or by reaching to the operator platform and using the starter switch. If the tractor is in gear, as soon as the engine starts the tractor begins to move forward, and the farmer, standing directly in front of the rear wheel, is run over. One manufacture has provided by-pass prevention kits to be placed on the starter in order to prevent the operator from doing this. Implement dealers comment that they put these on (at no cost) when a tractor is brought in for maintenance or resale but chances are pretty good that when they see that tractor again the kit has been taken off. Some tractor designs are such that the starter is in such an awkward location that it is
impossible for the farmer to by-pass start it, thus the tractor will be repaired as soon as there is a starting problem.

A survey on tractor usage conducted through the University of Iowa (Lehtola, 1992) asked farmers how often they had attempted by-pass starting during the past 12 months. For the tractors a farmer indicated he had by-pass started, he was likely to have done it whenever that tractor was used. Some farmers indicated they had by-pass started a certain tractor as many as 100 or more times during the course of the year.

The tractor is parked and begins to roll while the operator is off the tractor

There were 6 (3.5%) instances, including one fatality, of the tractor being placed in park, the operator getting off, and the tractor moving and running over or pinning the operator against an object. A common situation was that of the operator getting off the tractor to open a gate, the tractor was parked on an incline and began to roll. Since these situations occurred several times, the brake system may need some attention by engineers. Was it due to the fact that the brakes were improperly set to hold the tractor on the incline, and if so why? Was it due to the strength of the operator? If such is the case then the human element needs to be considered in order to effectively interface with the brake systems for stationary applications.

1991 IDPH data also indicated this as being a frequent cause of the tractor accidents reported.

A bystander or other person is run over

This involved two fatalities and three injuries. Two of the injuries were incurred when a grandfather backed the tractor over a young (3 years old or less) visiting grandchild, while one involved a father backing over his 7 year old son. Fortunately these instances resulted in minor injuries only.
One of the fatalities occurred when a wife was helping her husband grind feed on a winter evening (dark) and he backed the tractor and feed grinder as she was standing behind it.

Reverse warning horns or bells would perhaps have averted this devastating consequence.

The other fatality was the result of the farmer returning to the tractor he and his hired man had been working on. He did not see the employee and proceeded to start up and drive the tractor. The employee was working under the tractor. The inference here is the continual reminding of people on farms to "know where others are at."

**Motor Vehicle and Tractor**

Twenty-eight (16.2%) of the 173 incidents occurred on public roadways and involved other vehicles. The roadway incidents involved a total of 70 (32.1%) of the 218 persons involved in tractor related accidents due to all causes. Forty-two (60.0%) of these were vehicle occupants. Motor vehicle and tractor included eight fatalities, accounting for 9.2% of the 87 fatalities. Two of the fatalities were tractor operators and six were vehicle occupants. The three most frequent situations, based on total incidents were:

1. Tractor being hit from the rear (35.7%)
2. Tractor turning left while motorist attempts to pass (25.0%)
3. Head-on collision (21.4%)

Figure 14 shows this graphically.

Data aren't readily available for miles of public roads traversed by agricultural tractors; however, given the fact of fewer operators farming more acres, one has the impression that tractor use on public roads and highways is increasing.
Older tractors, less appropriate for road travel operation, are being used on roads and highways, along with increased vehicular traffic.

A Farm Journal (Ottey and Fink, 1990) survey asked 100 farmers what their machinery safety concerns were. The number one response was that of public road travel to reach fields [and markets]. Farmers also noted that road travel at night is compounded by larger, wider, equipment. It was further stated, "Faded SMV emblems, implements without brake or caution
lights, no turn signals and no clear differentiation between flashers and turn signals on tractors make road travel even more hazardous."

Recommendations and regulations for operation of equipment on Iowa's public roads are included in a brochure (IFSC, 1984) that is available for public distribution. These regulations are minimal at best and do not necessarily meet the needs of the motoring public. In addition to these recommendations and regulations, the ASAE is currently working on improved requirements for the lighting and marking of agricultural tractors and towed equipment.

**Tractor hit from behind**

This category accounted for the highest frequency scenario of the roadway, motor-vehicle incidents, accounting for one tractor operator fatality and 10 (35.7%) of the total incidents.

Primary causes included: speed of closure that is enhanced by the speed differential of the motor vehicle and a tractor; inadequate rear lighting and/or marking of tractor or towed equipment; and failure of motorists to recognize the hazard ahead of them.

Comments by tractor operators involved in rear-end collisions indicated that the motorist never even applied the brakes. This indicates the motorist did not recognize the tractor and the hazard it presented until it was too late to react.

**Tractor turning left while motor vehicle is passing**

The second most frequent category of tractor and vehicle incidents involved the situation where the tractor is pulling equipment or wagons and has obstructed visibility to the sides and rear; a vehicle approaches from the rear and as the vehicle attempts to pass, the tractor turns left into a farm or field drive thus hitting the vehicle.

This situation resulted in 2 fatalities to vehicle occupants and 1 fatality to a tractor operator. It accounted for 7 (25%) of the 28 motor vehicle incidents and 3 (3.4%) of the 87 fatalities.
This indicates a definite need for more explicit turn-signal devices on both tractors and equipment. Warning lights on newer tractors are continuously flashing; thus when a signal light flashes, a motorist isn’t aware of its meaning. Using a turn signal with a large directional arrow similar to that of school buses would be one recommendation to be considered. There also is a need for developing methods for providing better information to the tractor operator, such as with mirrors or cameras.

Location of the signal device is also a factor to be considered. For example, should the lighting on the rear of a grain wagon be located at the top of the wagon or at the motorist’s eye level? Even signal or warning lights at the top of the tractor cab may be too high for a motorist’s eye to see and readily recognize.

Haddon (1979:52) reported on the effect that placing a brake light in the middle of the rear windshield of cars had on reducing the number of rear-end collisions with New York City taxi drivers. The study indicated that:

Rear-end collisions were more than halved and the average repair cost in the case of the collisions that did occur was cut by more than a third. This was accomplished merely by giving following drivers better information, not by requiring that they somehow be reformed.

This is now a requirement on cars currently being manufactured.

**Head-on collision**

The head-on collision accounted for 6 (21.4%) of the motor-vehicle involved accidents, resulting in 4 vehicle occupant fatalities and no tractor operator fatalities.

The most tragic of these involved a newer model large tractor driven by a 17 year old boy. Accident reports indicate he was concentrating on a vehicle following him since he planned on turning left into the farm drive. He forgot to look for oncoming traffic, thus as he turned he was hit head-on by a car carrying five people. The tractor operator sustained minor injuries; 2
vehicle occupants were killed, one remains in a comatose state 2 years after the incident, and the other 2 sustained less severe injuries. This incident also provides an example of hidden costs of accidents and information that isn’t revealed by the immediate follow-up data collection forms. Since this accident occurred in the middle of the reporting cycle, it is now known (2 years later) that the consequences of this incident took a devastating toll of life and potential life that is unmeasurable. The tractor operator is mentally ill and in counseling and therapy, and the parents have discontinued the farming operation.

Other head on situations involved the scenario where the motor vehicle and tractor crest a hill on a gravel road, with both vehicles approximately in the middle of the road. Rural gravel roads are often narrow, thus vehicles and tractors travel more often in the middle than along the right side.

The tractor operator also often travels partly in the oncoming lane when towing wide equipment. In these circumstances the left side of the towed equipment may almost block the entire oncoming traffic lane.

Alcohol

Although alcohol is rarely publicized in news reports of tractor accidents, it was known to be a factor in at least four of the fatalities studied. This information was only made available through the sheriff’s office. The SPRAINS follow-up data collection procedure has been able to find out this information. In one instance, the tractor operator had had his driver’s license revoked due to OWI convictions and therefore used the tractor as his means of transportation.

Summary

Examples of events that occurred with high frequency were reported to be:

Overturns to the side and rear.
People being run over by tractors was the second largest category. These include operators and passengers falling off. All the passenger victims were children.

Motor-vehicles and tractor collisions accounted for the third highest category. Rear-end collisions were the highest type; followed by the tractor turning left while a motorist was passing; followed by the head-on collision.

This chapter has provided information about specific factors involved in tractor accidents as well as tractor accidents that occur with high frequency. This information is used in the next chapter, to develop an action plan and propose intervention strategies for reducing the number of tractor-related fatalities and injuries.
CHAPTER V.
TRACTOR RISK ABATEMENT AND CONTROL: AN INTERVENTION MODEL

Introduction

Approximately thirty Iowans are killed annually in tractor-related accidents. Methods to greatly reduce these numbers already exist. Reducing tractor-related deaths will not necessarily require invention, but rather coordination, implementation, and action.

The purpose of this study of tractor-related accidents was to identify factors involved in tractor-related accidents in order to identify and develop intervention strategies. The objectives of the study were:

1. To identify specific factors involved with tractor related accidents in Iowa during a three year period.
2. To analyze the effectiveness of possible intervention strategies.
3. To recommend effective intervention strategies.

Specific factors were identified in Chapter IV. This chapter addresses objectives two and three. Possible intervention strategies are analyzed and an intervention model is presented.

Intervention Models

The effectiveness of the rollover protective structure (ROPS) in preventing deaths from tractor overturns was reported in the Literature Review. The Sweden example was cited (Springfeldt and Thorson, 1987).

In 1959 Sweden mandated that ROPS be on all tractors manufactured. In 1965 ROPS were required on all tractors used. This meant that ROPS had to be retrofitted on all older tractors.
in operation. This resulted in the overturn fatality rate going from 19.5 per 100,000 tractors in 1959 to 0.5 per 100,000 tractors in 1978. The rate has held at 0.5.

This retrofit program was government subsidized (Gunderson, 1992). In order to obtain a rebate from the government, two conditions had to be met:

1. There had to be an approved ROPS retrofit package available for that particular tractor. This insured that test standards had been met and the tractor model had the structural integrity to withstand the impact forces imparted to it by the ROPS in the event of an overturn.

2. The retrofit ROPS had to be installed by a certified installer, usually the implement dealer. This requirement served to prevent improper installation, or installation of home-made ROPS.

However, other information must be considered when looking at this example. Sweden has a different form of government than the U.S. with people being more accepting of regulations. Sweden's farms are small, often less than 80 acres. Tractor sizes are typically less than 80 horsepower, with an average of one tractor per farm. With 80,000 farms, Sweden has less than one-third as many tractors as Iowa (Gunderson, 1992).

Skromme (1990) referred to a program in Canada where the government set aside an allowance for farmers to retrofit ROPS. He noted the program was effective; however, he further stated that the program was discontinued due to lack of funds. This emphasizes the need for an integration of resources, rather than being dependent on one source of funds.

The Swedish program was only effective for eliminating deaths due to tractor overturns.
Suggestions have been provided by other researchers for retrofitting ROPS on Iowa tractors. Kern (1990) stated that various agencies are working together towards accomplishing the two basic goals of creating a check-off system based on the sale of new equipment and developing an incentive program for farm families to receive reduced insurance premiums when they retrofit older equipment with ROPS and shields. Funds obtained from a check-off program could be used for helping farmers purchase retrofit ROPS and shields for older equipment.

Presently policy efforts are being considered towards reducing health insurance costs for families who do implement preventive strategies. However, this is an area where the insurance companies require evidence that prevention efforts will reduce their costs. This is an example of an area in which Iowa’s Center for Agricultural Safety and Health is assisting in policy development and change.

There was a national meeting at Des Moines, Iowa, in 1988 addressing agricultural safety and health issues. Results and recommendations of this session were presented in a national report by NCASH (National Coalition for Agricultural Safety and Health, 1989). The policy recommendation developed for ROPS, as stated on page 30, was:

Mandate the installation of rollover protection structures (ROPS) on all new tractors sold in the United States, and provide economic incentives to persons who retrofit ROPS on their tractors within the next five years, while requiring ROPS to be installed on all tractors within ten years. Economic incentives may include tax incentives and private sector initiatives such as insurance rate modification schemes or low or no interest loans from rural lenders.

Kelsey and Jenkins (1991) in New York State analyzed the feasibility of meeting this NCASH recommendation for their state. They estimated 59,873 tractors would need to be retrofitted and they estimated the average cost of an installed retrofitted ROPS to be $700. New York has a yearly average of nine fatalities due to tractor overturns. Kelsey and Jenkins felt
enforcement of a mandatory ROPS policy would have the greatest influence on the effectiveness of such a policy, but would also be its largest expense.

The study mentioned that economic incentives would be required, but did not outline a specific plan or give specific suggestions.

They estimated that the cost per life saved would equal $511,136 assuming ROPS were 100% effective in saving lives. They noted results from a study that had reviewed 35 different life-saving programs of various types. Cost per life saved was estimated at no cost for compulsory seat belt use, $408,000 for mandatory air bags, $1,200,000 for the 55 mph speed limit, and over $3,500,000 for policies regulating toxic substances.

In California, UNOCAL (UNOCAL, 1991) sponsored a private program (no public funds were used) of buying older cars (older than 1970) and scrapping them. This was done for the purpose of reducing air pollution. A similar program could be established for eliminating older tractors without ROPS that are in use. It is well known in agriculture that tractors last a long time and even the older ones are projected to be in use for another 20-30 years. Enough people have died. Results need to be obtained sooner than that!

The UNOCAL program paid the person $700 for the car when it was delivered to the scrap yard. A total of 8,376 cars were purchased. UNOCAL had two requirements, 1) in order to assure it was a car that was in use it had to be driven to the scrap yard and 2) in order to prevent illegal activity the person had to show proof of a clear title to the car.

If this model were to be applied to tractors, the implement dealer could pick up tractors that met specific qualifications and scrap these tractors. Priority would be given to those models for which a retrofit ROPS is not available. As indicated in the Swedish example, there are some
tractors for which a retrofit ROPS package is not available due to lack of structural integrity of the tractor.

Second priority for purchase and scrapping would be given those tractors where the cost of the retrofit exceeds the value of the tractor.

Interventions that only have to be done once are more effective than those that require repeated correct behavior. An illustration of this is the effectiveness of a one-time vaccination against a disease compared to the acceptance and adoption of the behavior of having to buckle ones seatbelt upon getting into a car.

If all tractors were equipped with ROPS and the seatbelt was used, there would be no overturn fatalities. The Swedish rate has held at just above zero, indicating that there may be one overturn fatality every other year at the most. Seatbelt use is not required with a ROPS in Sweden (Thelin, 1991).

Tractors manufactured in the U.S. since 1985 have a ROPS as standard equipment, thus there are no new tractors entering Iowa's fields without ROPS (unless a farmer takes it off, but this is becoming rare). Therefore, attention needs to be focused on the older equipment still in use. Older equipment has fewer and less effective safety features than does newer, e.g., lighting and marking, shielding, and ergonomically designed controls and seating.

Death rates in industries have declined, primarily due to OSHA regulations and requirements by insurance carriers (Skromme, 1990), resulting in workplace safety meetings and training (education); required shielding and interlocks on industrial equipment (engineering); use of protective clothing; and other requirements designed to guarantee workers a safe place to work.
Industries set the prices of the goods they sell, thus the costs of the above programs are ultimately passed on to the consumer. However, complying with safety practices does result in lower liability insurance rates, and diminishes the risks of being fined by OSHA.

Development of an Intervention Model

The examples of intervention strategies and recommendations were cited to assess their usefulness in developing a tractor risk abatement and control model to reduce tractor-related deaths in Iowa.

The United States Public Health Service spent three years developing a national strategy for improving America's health during the next ten years. This document set forth target goals to be achieved by the year 2000. In the cover letter introducing the document, the Assistant Secretary for Health James Mason, (Public Health Service, 1991:iii) stated:

This set of objectives for the year 2000 makes an important, compelling point to us and to all health policy makers: we can no longer afford not to invest in prevention. From the perspective of avoiding human suffering as well as saving wasteful costs for treating diseases and injuries that could have been prevented, the 1990's should be the decade of prevention in the United States.

The study focused primarily on health problems common to all Americans, e.g., heart disease and cancer. A small portion dealt with occupational safety and health, of which one objective was targeting work-related fatalities. The target set forth for work related fatalities was to reduce the deaths from work related injuries by one-third.

The only statement made in reference to a specific prevention strategy for reducing work-related deaths states (p. 300):

The prevention of severe trauma rests on the basic principles of control technology: engineering controls, work practices, personal protective equipment, and monitoring of the workplace for emerging hazards.
This document can assist in developing rationale for a challenging but realistic target goal for tractor fatality reduction in Iowa. Accidental deaths reported by the National Safety Council (NSC) annually for all industries (excluding agriculture) range from nine to eleven per 100,000 workers. The rate of 10 per 100,000 workers can be used for target purposes. The rate for agriculture was noted in Chapter II as approximately 50 per 100,000 workers. A realistic target would be to reduce the number of agricultural fatalities to the same as that for other industries. Thus, agricultural fatalities would have to be reduced by 80%, from 50 to 10 per 100,000 workers.

Iowa could provide a model for the nation in demonstrating the effectiveness of a plan of action for reducing tractor-related deaths by 80% during the next five years. Although no death is acceptable, it is recognized that in a state with an estimated agricultural work force of 110,300 (Iowa Farm Bureau, 1990) and a tractor population of 302,000, deaths will occur. A realistic target would be that Iowa average no more than six tractor-related deaths per year.

The program goals (based on 30 tractor-related fatalities per year) would be that Iowa's tractor-related fatalities would be reduced by 20% (6 lives saved) for each of the first four years of the program. The fifth year would be a transition to a maintenance goal of no more than 6 fatalities per year. Through an integrated multi-disciplinary approach, this is a realistic goal, even during times of limited resources within the state.

Based on this goal, a tractor risk abatement and control intervention model was developed. Considerations in developing the model included: estimating an economic value for life lost, prioritizing the intervention focus, and identifying resources for intervention.
Estimating the value of life lost

Researchers, insurance companies, and policy-makers have difficulty in placing a value on life, or in the case of an accidental death, the value of the life that was prematurely lost. It is understood that it may appear crass or insensitive to do so. In an effort to place a quantitative value on the cost of accidents, injury prevention specialists have developed a number to establish an estimate of Years of Potential Life Lost (YPLL). This is estimated by subtracting the age at death from a specific number. Generally the set value is based on 65 years, where 65 was considered the most frequent retirement age (National Committee for Injury Prevention and Control, 1989:5).

Since many farmers continue to farm or participate in farm related activities after age 65, the YPLL used herein is based on 75 years.

A limitation to the YPLL estimation is that if someone was older than the age considered (i.e., 75 years), their death is not included. It needs to be emphasized that all life has value, but in order to make estimations, it is necessary to define an index number.

The Iowa tractor-related fatalities (1988-90) resulted in 2,181 years of potential life lost, for an average of 25.5 years per victim (87 victims). A summary of these results by cause are shown in Table 18.

The use of the YPLL estimation shows that the loss due to extra riders is a more severe problem than fatality numbers alone indicate. Extra riders accounted for 5.7% of the total number of deaths, however, 15.5% of the total YPLL was due to this cause. All the extra rider fatalities were children.
Table 18. Years of potential life lost (YPLL*) by tractor-related deaths, Iowa 1988-90
N=87

<table>
<thead>
<tr>
<th>Cause</th>
<th>Victims</th>
<th>%N</th>
<th>YPLL (years)</th>
<th>% of YPLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overturn</td>
<td>51</td>
<td>58.6</td>
<td>1124</td>
<td>51.5</td>
</tr>
<tr>
<td>Extra riders</td>
<td>5</td>
<td>5.7</td>
<td>338</td>
<td>15.5</td>
</tr>
<tr>
<td>Motor vehicle/tractor</td>
<td>8</td>
<td>9.2</td>
<td>151</td>
<td>6.9</td>
</tr>
<tr>
<td>Vehicle occupants</td>
<td>6</td>
<td>6.9</td>
<td>137</td>
<td>6.3</td>
</tr>
<tr>
<td>Tractor operator</td>
<td>2</td>
<td>2.3</td>
<td>14</td>
<td>0.6</td>
</tr>
<tr>
<td>Pinned while hitching</td>
<td>3</td>
<td>3.4</td>
<td>126</td>
<td>5.8</td>
</tr>
<tr>
<td>Fell from: no seat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>belt present</td>
<td>4</td>
<td>4.6</td>
<td>69</td>
<td>3.2</td>
</tr>
<tr>
<td>Seat belt available:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>didn't use (bounced from seat)</td>
<td>2</td>
<td>2.3</td>
<td>16</td>
<td>0.7</td>
</tr>
<tr>
<td>By-pass starting</td>
<td>2</td>
<td>2.3</td>
<td>23</td>
<td>1.0</td>
</tr>
<tr>
<td>Backed over</td>
<td>1</td>
<td>1.1</td>
<td>25</td>
<td>1.1</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>12.6</td>
<td>309</td>
<td>14.2</td>
</tr>
<tr>
<td>Total</td>
<td>87</td>
<td>99.8</td>
<td>2181</td>
<td>99.9</td>
</tr>
</tbody>
</table>

*YPLL based on 75 years
Note: Number of victims that were > age 75 = 7

There is no set economic value for the worth of one year of life. The following rationale was used to set a value for the purposes of this study.

An absolute minimum value could be based on the rate of minimum wage for 2000 working hours per year. Based on a minimum wage of $4.65 per hour, one year of life would have a value of $9300.

The 1990 Iowa Farm Costs and Returns (ISU Extension, 1991) provides a value for operator labor of $1200 per month. Using this as an estimated value, a member of the farm population would have a minimum earning potential of $14,400 per year. Thus for purposes of obtaining a base minimum value estimate, the range from $9300 to $14,400 can be considered. For estimation purposes, the figure of $10,000 per year of life was used.

Iowa averaged 727 years of potential life lost per year for the three year study.
Based on the above assumptions and estimations, Iowa has lost a minimum of $7.27 million per year in tractor-related deaths (assuming constant dollars). This value represents lost earning potential resulting from fatalities; it does not include medical costs, costs of injuries, nor costs associated with permanent disabilities.

**Prioritizing intervention focus**

It has been stated that an overall strategy for mitigating deaths and injuries due to tractor related accidents must be an integrated, multi-disciplinary approach. No single agency or source can effectively perform the task, but by working together it can be accomplished.

Previously in this chapter, a target fatality reduction of 80% was set. Proposals are now presented to reach that target. In order to have the most impact, it is necessary to focus on those causes that are high both in numbers of fatalities as well as years of potential life lost.

Based on years of life lost, the three highest categories of tractor accidents were: overturns (51.5%), extra riders (15.5%), and tractor and motor vehicle collisions (6.9%).

Priority must be given to developing strategies for reducing the number of fatalities due to tractor overturns, with the category of extra riders being second.

**Identifying resources for intervention**

With the identification and prioritization of tractor related fatality causes, effective intervention strategies can be designed in order to reach the defined target goals. It was previously stated that these interventions will not necessarily require the development and invention of new technologies, but can be achieved by activating and using technologies and resources that already exist. However, some items may have to be considered in new ways or approached differently than previously has been the case.
The likelihood of success in reaching the target goals will be greater if existing technologies are used where appropriate. This is due primarily to two factors:

1. New technological advances by industry take long amounts of lead time. A prime example was the adoption of rollover protective structures (ROPS) as an industry standard. The amount of time between ROPS being developed and ROPS being promoted exceeded 20 years. This was noted in Chapter II.

2. Technologies are frequently developed for new equipment being manufactured. However, many farm tractors in use are older and they will remain in operation for many years to come. It was described in Chapter IV that the older tractors are the ones that have been involved in the largest proportion of fatalities.

Resources for Intervention

Networks and resources that currently exist and the participatory role that each would take are outlined as follows:

Iowa's Center for Agricultural Safety and Health (I-CASH): I-CASH was described in Chapter II as having been established by the Iowa legislature for the purpose of efficiently and effectively using Iowa's agricultural health and safety resources for the benefit of Iowa's farm families. I-CASH involves cooperation and coordination between The University of Iowa Institute of Agricultural Medicine; the Iowa State University Cooperative Extension Service through the office of the Extension Safety Specialist; the Iowa Department of Public Health; and the Iowa Department of Agriculture and Land Stewardship.

One of the five focus areas of I-CASH is the reduction of tractor related injuries and fatalities.
Based on the mission of I-CASH, it would be beneficial to Iowa to use this resource as the central coordinating body in charge of coordinating, channeling, and facilitating tractor-related intervention strategies.

Iowa Farm Safety Council (IFSC): Members of IFSC are comprised of a variety of people interested in promoting the safety and well-being of Iowa’s farm families. Membership is voluntary and consists of farmers, agricultural educators, engineers, insurance companies, health and safety professionals, and other concerned citizens.

The IFSC would enhance intervention measures by facilitating networking in local communities, as well as facilitating dissemination of information through local and statewide networks. During its 50 years of existence efforts of this group have had a positive impact on agricultural safety initiatives in Iowa.

Both I-CASH and the IFSC have worked together on state-wide activities. This unique combination has great potential for bringing about safer farming in Iowa. IFSC relies on donations, dues, and volunteers; it is not publicly funded.

Farm Safety For Just Kids (FSFJK): Farm Safety For Just Kids has been developed to promote agricultural safety activities among young children and youth. This organization originated and is based near Des Moines, Iowa. It has received national recognition and is developing local chapters similar to 4-H and FFA.

Tractor manufacturers: Manufacturers have expressed interest in assisting with intervention programs. They may provide incentives and promotions for dealers to have a tractor safety day with demonstrations and activities. They are also interested in promoting the retrofitting of ROPS.
Banks: Banks have power and influence in the rural community. They have offered to help by sponsoring intervention and educational programs. One example has been providing scholarships for youth to attend a farm safety day camp activity.

Local communities: It was stated in Chapter II, that for interventions to be effective they must ultimately be implemented at the local community level. Additionally, community people must be involved in the program planning process. This involves the networking and interaction of community individuals as well as organizations.

Health network: Iowa is unique in that it has several health agencies involved with agricultural safety and health. Iowa's Agricultural Health and Safety Services Program (IA-HASSP) has nine clinics in Iowa. The Iowa Department of Public Health has four nurses regionally located. They obtain accident surveillance information as well as present educational programs. The geographical distribution of these existing networks is advantageous for disseminating items statewide. The IA-HASSP and IDPH agricultural nurse networks have interacted effectively with local extension personnel in the development and dissemination of local programs. They have been instrumental in coordinating and facilitating local agricultural safety day camps.

Department of Education: The audiences to focus in the education network are local agricultural educators as well as community college educators. Agricultural educators are those that frequently conduct tractor operator training classes. As advisors for FFA chapters they have potential to reach many of Iowa's farm families. Community Colleges are able to offer continuing education programs to adults in the form of workshops and training sessions.

Enforcement: Regulation setting and enforcement would take place through existing channels. Establishment of new regulations would be implemented as a result of actions of the
Iowa State Legislature. The key enforcement agency would be the Iowa Department of Public Safety (IDPS) law enforcement officials who have jurisdiction on public roadways.

Local businesses: Businesses are a part of local communities. An additional item of importance is the facilitation for making safety items available locally. People follow the path of least resistance. Recommended safety equipment will not be used if it is not readily available.

Frequently, in reference to assisting with farm safety items, emphasis is placed on equipment companies and the agribusiness sector. However, all businesses in the community benefit from farmers staying alive, healthy, and in business. It was stated in a recent presentation (Williams, 1992) that rural communities lose one business for every five to seven farmers that discontinue farming. A hidden cost of serious farm accidents is that often the family will discontinue farming, especially if the farm operator is killed.

An example of local businesses facilitating safety practices and the use of protective equipment (such as ROPS installation) would be to offer a coupon packet as an incentive reward. This could be given to the farmer when safety equipment is purchased. Coupons could include free restaurant meals, free groceries, and other free or discounted items offered by all businesses in the community. However, it should be noted that the financial responsibility must not be solely that of the agribusiness sector.

Farmers: Farmers must be an integral part of the entire program planning process. Also as farmers adopt innovations, other farmers are influenced. Acceptance of program incentives is crucial to the success of a program. Peers must be in the forefront in attitude change.
Policy groups: A policy group needs to be established for the purpose of recommending policy to the state legislature. The policy group would be coordinated through I-CASH, but would consist of representatives from other industries and agencies throughout the state.

McKnight (1984:38) stated:

No countenance, regardless of its potential loss reduction effectiveness, will promote the public health so long as prevailing social, political, and economic forces prevent its adoption.

The purpose of the policy group would be to address the social, political, and economic forces that are presently hindering the innovation and adoption of safety measures. These may include recommendations for liability award limits, regulations, insurance incentives, and loan requirements.

Figure 15 diagrams the interaction of these groups. Iowa is unique in that most of these networks are already in place. Iowa can be on the cutting edge of implementing an effective tractor risk abatement and control (TRAC) program.

Additionally, The University of Iowa is already conducting a pilot TRAC project targeted at two counties in northeast Iowa. The objectives of the TRAC project are similar to those that would be applicable on a statewide basis.

The pilot TRAC project, funded though the Centers for Disease Control (CDC), is scheduled for completion and evaluation in September 1993. Results of that program could be readily adapted to a statewide program with very little lead time required. Objectives of the pilot TRAC project are (Lehtola,1992):

1. To reduce tractor-related fatalities and injuries.
2. To promote the involvement of community businesses, agencies, and resources.
Figure 15. TRAC intervention groups
3. To facilitate a smooth transition of the project to local agencies when the university sponsored portion is completed.

4. To evaluate the program's over-all effectiveness.

5. To adapt and apply the model on a larger scale (e.g. statewide).

**Presentation of the model**

The intervention model is shown in Figure 16. The model presented is based on an estimated Iowa tractor fatality number of 30 per year. Of these, 17 are estimated due to overturns, while two are due to extra riders. When developing the model, the assumption was made that deaths in both of these categories could be reduced to zero.

Since accidents are relatively rare events, the model presented is conceptual, and exact numbers will fluctuate from year to year. However, the 80% reduction over five years is realistic.

This model differs from interventions cited from the literature in that it is based on all tractor related causes, rather than only looking at deaths due to overturns.

The data from this study as well as other experiences documented in the literature indicate that the use of the rollover protective structure (ROPS) does indeed save lives (Schneider, 1983; Springfeldt and Thorson, 1987). In Iowa, there have been no fatalities in an overturn involving a tractor that was equipped with a ROPS. ROPS does not prevent the overturn from occurring, but in the event that it does occur, the tractor operator is protected.
### Current

Tractor-related deaths per year $N = 30$

1. \(17\) = overturns
2. \(2\) = extra riders
3. \(3\) = motor-vehicle/tractor collisions
4. \(2\) = fell from and run over
5. \(1\) = by-pass starting
6. \(5\) = other

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Planning</td>
<td>Education:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Coordination</td>
<td>Year 1 (Con’t)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education:</td>
<td>Focus on target</td>
<td></td>
<td></td>
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<tr>
<td>Operator Training</td>
<td>audiences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness of ROPS</td>
<td>Engineering:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative Usage</td>
<td>Retrofit of ROPS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Riders</td>
<td>Buy-back Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enforcement: No Riders</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce deaths by 20%</td>
<td>Reduce deaths by 20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$N \leq 24$</td>
<td>$N \leq 18$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 OT</td>
<td>5 OT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Extra Riders</td>
<td>1 Motor Vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal: $N \leq 6$ deaths per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 16. Tractor risk abatement and control model for Iowa
Education efforts need to focus on the use and effectiveness of ROPS. Many farmers have the misperception that ROPS will interfere with a tractor's usage (Lehtola, 1992), when in actuality once they do use a tractor with a ROPS, they have found that it does not interfere (Pelton, 1990; Baumler, 1992). Demonstrations need to be performed to dispel this false perception. Preliminary results of tractor usage conducted at The University of Iowa (Lehtola, 1992) indicated that two-thirds of the farmers who operated tractors with ROPS under hazardous conditions (e.g., slopes) did own a tractor that was equipped with a ROPS. An initial focus could be on interventions involving a minimum expenditure for farmers, i.e., showing the farmer that he already owns a safer alternative and could use the tractor that is equipped with the ROPS for those tasks presenting a higher risk of overturn.

The second item to focus on is eliminating passengers riding on tractors. These tragedies most often involve children. All of the five rider fatalities in Iowa during the three years were children. This category involved 5.7% of the total fatalities but accounted for 15.5% of the Years of Potential Life Lost. Both education and enforcement, will be required to eliminate these deaths.

Children do not belong as passengers on a tractor. In addition to being subject to falling off and being run over, they are exposed to dusts, chemicals, noise, and vibrations. These are known to have chronic detrimental effects on the human system (National Coalition for Agricultural Safety and Health, 1989). Since children are not essential to the performance of the task, there is no reason for unnecessarily exposing them to these hazards.

Regulations are not of value if they cannot be enforced. The situation with agriculture is that it is not practical to enforce what a farmer does in the field. However, a regulation not permitting tractor passengers on public roadways is enforceable. Such a regulation would be
under the jurisdiction of local law enforcement officials and highway patrols. Although, this in and of itself would not eliminate tractor passengers, it may deter some from taking their children with them. If a person cannot ride on the tractor on the road to the field, it is less likely they will find an alternative way to get to the field just to ride on the tractor. Fines collected could go toward farm safety programs and efforts.

A strategy for getting tractors retrofitted with ROPS would be a part of the program. The TRAC program budget would be approximately $200,000 per year of public funds. This would include coordination and program development. The budget of $200,000 of state funds was estimated from current costs indicated in the I-CASH Annual report (Iowa’s Center for Agricultural Safety and Health, 1992:34). The project would require 2.0 full-time equivalents (FTE) working as tractor injury prevention specialists for each of the first four years. Year five could be scaled back to 1.5 FTE. After five years, it is felt that maintenance could be provided with a 0.5 FTE devoted to tractor injury intervention. Main items of this budget are outlined as follows:

**TRAC Yearly Program Budget**

<table>
<thead>
<tr>
<th>State (Public) Funds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two FTE tractor injury prevention specialists @ $54,000 each</td>
</tr>
<tr>
<td>Two FTE support staff @ $22,000</td>
</tr>
<tr>
<td>(secretarial, copying, administration)</td>
</tr>
<tr>
<td>Supplies:</td>
</tr>
<tr>
<td>(including copying, displays, mailings)</td>
</tr>
<tr>
<td>Travel (extensive statewide, professional meetings)</td>
</tr>
<tr>
<td>Computer Maintenance and Service</td>
</tr>
<tr>
<td>Other Expenses:</td>
</tr>
<tr>
<td>(e.g., administration, indirect costs, library, video production)</td>
</tr>
<tr>
<td>Project Promotional Items</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Figure 17. TRAC yearly program budget
ROPS usage is the single most effective strategy for eliminating the number of tractor related fatalities. The focus beginning in the second year would be aimed towards getting ROPS installed on those tractors that are used in high-risk situations. This could be done by the retrofitting of ROPS onto existing tractors not already so equipped, as well as by encouraging the tractor owner to replace the tractor that does not have a ROPS with a tractor that does. If a tractor without a ROPS is traded to a dealer, and it is a model where the cost of retrofitting a ROPS would be greater than the value of the tractor, then the manufacturer may be asked to share in the cost and allow the farmer value on a trade-in. The non-ROPS tractor would then be scrapped by the dealer rather than being placed back in service. Dealers would only be able to sell or lease tractors equipped with ROPS, regardless of tractor age.

Additionally, banks, manufacturers, and finance companies could have the authority to deny loans for the purchase of tractors that are not equipped with a ROPS. Banks could also refuse operating loans for farmers that have no tractors equipped with a ROPS. One incentive would be for banks and finance companies to offer lower interest loans for the purchase of tractors equipped with ROPS or for a loan for retrofitting ROPS.

Based on information from a publication (Farm Auction Clearinghouse, 1992) summarizing prices obtained for tractors from midwest auction sales, an average value of $1000 was placed on older narrow front tractors. The average cost of retrofitting of ROPS (based on the Marshfield Directory) would be $400-$800. Realistically, most of these tractors are not going to be retrofitted with ROPS.

The tractor population is estimated at 302,000 for the state of Iowa. An estimate of the percentage of narrow front tractors in use is 25%. We are thus looking at attempting to eliminate 75,500 tractors from Iowa’s tractor force and replacing them with safer tractors that
have a wide front and are equipped with a ROPS. There are also older wide front tractors in use without ROPS so this would add to the target number; however, many of these may be of more value, and therefore it may be feasible to invest in a retrofit ROPS for them.

Since this would be an elimination project, it would be a one-time cost. Not all of the tractors targeted for buy-out would have to be purchased in one year. This could be spread over the five years of the program. If this were evenly distributed, it could be performed at an annual cost of $15.1 million, however, this would not necessarily have to be public funds, but could be shared by manufacturer's, society, and farmers.

Manufacturers could share in costs by offering trade-in incentives for tractors without ROPS. If a ROPS cannot be retrofitted, the tractor would be permanently scrapped. It should be emphasized that selling these tractors to other states is not an acceptable solution to Iowa's problem since tractors without ROPS are considered dangerous machines.

It is difficult to obtain and therefore estimate costs to manufacturers and dealers of such a program, since that is generally considered proprietary information. However, manufacturers would readily participate since they benefit in the following ways:

1. Decreased liability concerns (they are still held liable for tractors made 50 years ago).
2. Increased sales of higher priced tractors when a person trades in and buys "up".
3. By eliminating the older tractors, the necessity to keep producing and supplying older parts is removed.

Society should be expected to absorb costs, since everyone benefits from agriculture. It has been stated, "anyone who eats is involved in agriculture." Therefore society should be expected to pay some costs for enhancing farmer's safety. It was shown that the basic
education and program coordination package would cost an estimated $200,000 annually. This was anticipated as being funded by society (taxpayers).

Farmers themselves have a very powerful mechanism whereby they can help themselves and each other. Commodity groups, in the past, have assessed check-off charges to units of commodities produced for such activities as product promotion and research.

Table 19 shows the amounts that could be obtained for different options of check-off amounts.

Estimates of commodity units were obtained from the 1990 edition of Facts on Iowa Agriculture (Iowa Farm Bureau, 1991), for Iowa’s main products.

- Beef production: 28.47 million cwt* sold
- Pork production: 55.15 million cwt* sold
- Dairy production: 42.02 million cwt* milk sold
- Soybeans produced: 322.92 million bushels
- Corn produced: 1,445.50 million bushels

*cwt = 100 pounds

<table>
<thead>
<tr>
<th>Commodity</th>
<th>1 cent per unit</th>
<th>1/2 cent per unit</th>
<th>1/4 cent per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (cwt)</td>
<td>.29 million</td>
<td>.14 million</td>
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<td>Pork (cwt)</td>
<td>.55 million</td>
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<td>Dairy (cwt)</td>
<td>.42 million</td>
<td>.21 million</td>
<td>.10 million</td>
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<td>Soybeans (bu)</td>
<td>3.23 million</td>
<td>1.61 million</td>
<td>.81 million</td>
</tr>
<tr>
<td>Corn (bu)</td>
<td>14.46 million</td>
<td>7.23 million</td>
<td>3.61 million</td>
</tr>
<tr>
<td>Total ($)</td>
<td>18.95 million</td>
<td>9.47 million</td>
<td>4.73 million</td>
</tr>
</tbody>
</table>
Consumers pay for the safety of those working in processing and manufacturing through costs passed on to the consumer. A source of funds for farmers' safety devices could come from a charge to food products sold.

The economics department at Iowa State University has estimated that for 1991, $2.41 billion of food (non-taxable) products were sold through Iowa's grocery stores (Stone, 1992).

A 1% charge on this value would result in $24.10 million per year. It would be recommended that these monies be added to the cost at the processor or wholesaler level, rather than being classified as a consumer tax. In Iowa, food items are exempt from the 5% sales tax.

A combination of commodity check-off and a grocery charge could be utilized in obtaining program funds.

Previously reference was made to check-off amounts on sales of new equipment. If the commodity check-off is being considered, the equipment check-off should not be considered, since it is felt that both of these are paid for by the farmer. Since all of society is concerned, the grocery charge appears to be a better funding source that spreads the costs proportionately with what people consume.

It was estimated in Chapter II that 66% of the tractor population (both nationally and in Iowa) is not equipped with ROPS. Based on Iowa's 1987 tractor population of 302,000, there are 199,320 tractors without ROPS. This is a maximum value since the tractor population is estimated to be decreasing (Iowa Farm Bureau, 1991).

Included in these 199,320 are the 75,500 narrow front tractors which would be targeted for buy-back. Therefore there are an estimated 123,820 tractors that would require a ROPS retrofit package. Based on the ROPS directory as well as the New York State study (Kelsey and
Jenkins, 1991), an average cost for a ROPS package would be $800. The cost to retrofit Iowa's tractors would be $99.1 million.

Averaging buy-backs and retrofits over the five years of the program would require that 15,100 tractors be purchased yearly, with 24,764 being retrofitted annually.

The following proposal shows, that with a combination of a check-off amount of 0.25 cents per commodity unit ($4.74 million annually) and a 1% grocery charge ($24 million annually), all tractors without ROPS could either be taken out of service or retrofitted with ROPS during the five years of the program. This is based on paying 100% of the buy-back program (estimated at $1000 per tractor); and cost-sharing of the retrofit program as follows:

Tractor owner = 30% (tax deductible)

Grocery charge = 58%

Commodity check-off = 12%

This proposal involves no federal funds.

Cost-sharing would also assure installation of only approved ROPS as well as correct installation.

A maintenance program needs to be established to take effect upon completion of the main program that has been outlined.

The tractor risk abatement and control program could be maintained at a public cost of $50,000 per year, with a 0.5 FTE injury prevention specialist. Primary focus would be towards coordinating tractor operator training programs, as well as working on strategies for reducing the remaining tractor fatalities. Examples include working towards better lighting and marking, hitching of equipment from the tractor seat, and reverse warning mechanisms.
Education efforts need to be maintained. Safety research has indicated that when an educational program aimed at specific hazards is discontinued, that in three years the fatalities again increase. This illustrates the principle that people need reminders in front of them continuously, rather than a strong one-shot program whose effectiveness decreases with time.

Educational efforts need to focus on actual training programs and not rely exclusively on approaches that involve hand-outs, and/or lectures. This may be analogous to the present example of the pesticide applicator training program which includes a recertification refresher course. As people become familiar with a machine, they often become complacent. Initial proper training, as well as refresher training needs to be promoted.

Summary of intervention model

The tractor Risk Abatement and Control (TRAC) intervention model, presented in this chapter, outlined a set of strategies that can realistically be utilized to eliminate 80% of Iowa's yearly tractor-related deaths over a five year period. In order to get attention and be effective it is necessary for the program to be aggressively promoted.

Iowa can be a model for the nation by utilizing the unique resources and network the state already has available. The Iowa Center for Agricultural Safety and Health (I-CASH) promotes and requires interaction of the Iowa Department of Public Health, the Iowa Department of Land Stewardship, Iowa State University, and The University of Iowa. Iowa is one of only a few states with this type of network. I-CASH has been established by the Iowa Legislature and is already working.

The costs for the strategies set forth are estimated to be $175.5 million for the five years of the program. This would be an estimated $35.1 million per year. Maintenance costs for years following complete program implementation are estimated at $50,000 per year. Program costs
would be divided among farmers, society, commodity groups, manufacturers and communities. The fund sources suggested were based on Iowa products, with no federal funds used. Many of these costs go for interventions that only need to be done once. The estimated cost per life saved would vary from $2.1 million at five years to $390,000 per life by year 20. Eighty-four lives would be saved in the first five years, and 444 lives in 20 years.

Program costs of 35.1 million annually, divided over Iowa's farm population result in an average cost of $351 per farmer. Surely this is not too high a price to save these lives.

At the present rate, Iowa loses an estimated $7.27 million (minimum) per year due to total years of life lost in tractor-related fatalities. This does not include costs of injuries. It is recognized that strategies that reduce fatalities are also effective in reducing the number of injuries as well as injury severity.

Twenty four lives per year would be saved, with an estimated minimum value of $5.82 million.

Based on monetary value alone, the model presented would take a projected 32 years for the benefits to equal and surpass the costs. The program costs are high initially, then taper off after year five. Since the program, as presented, would take what appears to be a long-range projection for a break-even consideration, alternative program designs need to be considered. Examples of alternatives to consider would be, identifying a proportion of the tractor population for buy-back or retrofit; as well as considering criteria based on tractor usage, as well as safer alternatives that an operator may already have (i.e., the farmer with no ROPS should have priority over the farmer who has four tractors with a ROPS).

The strategies set forth in this proposal are feasible and realistic. Strategies presented included: educational programs for awareness and training, including tractor operator training;
eliminating usage of tractors without ROPS through buy-back and retrofit programs; and enforcement interventions for no riders on public roads, no sale or lease of tractors without ROPS, and no loans for farms using tractors without ROPS.

In the current climate of limited resources and increased accountability can society continue to afford the loss of $7.27 million per as well as the associated human suffering? Research studies have presented statistics for decades, with no real changes demonstrated over the years. Items contributing to agricultural accidents, cited in Chapter II from Shanks (1931) study, are no different than the hazards existing today. In order to effect a change in these accident statistics, an action plan needs to be implemented without waiting another 60 years.

Iowa needs to invest in its most important non-renewable resource of sustainable agriculture, the farmer.

Iowa does have the resources, personnel, interest, and capabilities to virtually eliminate tractor-related deaths and injuries. Iowa has a unique network of professionals and organizations that can accomplish this task. This network can make a difference.

Programs effective in Iowa will serve as a national model for eliminating the 600 tractor-related deaths reported annually nationwide.
CHAPTER VI.

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This study was implemented to obtain a better understanding of tractor-related accidents in Iowa and to develop intervention strategies. This chapter is divided into the following subheadings: summary, findings, conclusions, recommendations for action, implications, and recommendations for further research.

Summary

Objectives developed for this study were:

1. To identify specific factors involved with tractor related accidents in Iowa during a three year period.
2. To analyze the effectiveness of possible intervention strategies.
3. To recommend effective intervention strategies.

The data source consisted of 173 tractor related accidents reported in Iowa newspapers for the three years of 1988, 1989, and 1990. Follow-up information was obtained through the Iowa Department of Public Health and the county health nurse network.

The data was analyzed in two forms of presentation. Factors involved in tractor-related accidents were identified; and accident categories that occurred with high frequency were categorized and described.

Intervention programs were identified and a tractor injury intervention model for Iowa was developed.
Findings

The analysis and investigation of the data resulted in the following findings:

1. There were not sufficient data points to establish statistical significance. However, observation indicated that regions of the state with hillier topography and year-round livestock operations had higher numbers and higher fatality rates than other regions of the state.

2. August had the highest number of fatalities, while June had the highest number of incidents.

3. It was observed that Monday had the highest number of reported incidents as well as fatalities.

4. The accidents peaked at 11:00 a.m. for the morning with 4:00 p.m. being the peak for the day.

5. Males were predominately involved as tractor operators. Females that were victims were due to being a passenger on a tractor, occupant of a motor vehicle, or a bystander.

6. The age category of 41-60 accounted for 32% of the fatalities, and the group older than 60 years accounted for 37% of the fatalities. Children age 12 and younger were involved in 4.6% of the fatalities, none were operating the tractor, but all were extra riders on a tractor.

7. The tractors older than 10 years were involved in the greatest proportion of tractor-related accidents for those where the tractor age was identified.

8. The narrow front tractors were involved in the greatest proportion of tractor-related accidents for those where the tractor type was identified.
9. The tractor overturn accounted for 58.6% of the fatalities. The side overturn was most prevalent (82.2%).

10. There were no overturn fatalities with tractors equipped with a rollover protective structure (ROPS). All the overturn fatalities were with tractors not equipped with a ROPS.

11. None of the tractor operators indicated they used the seat belt.

12. Runovers of tractor operators or others accounted for 18.4% of the fatalities, this included operators falling off the tractor as well as passengers falling off and being run over. All the passenger fatalities (5.7%) were children with an average age of 7.5 years.

13. Sixteen percent of the total incidents involved other vehicles on public roadways. The most frequent scenario was the tractor being hit by the motor vehicle from the rear (35.7%). Twenty-five percent of the incidents occurred when the motor vehicle attempted to pass, and the tractor turned left.

14. Alcohol was a contributing factor in at least 4.6% of the fatal accidents.

15. An intervention model action plan was developed and proposed for reducing these fatalities by 80% over the next five years to a maximum of six per year.

Conclusions

Based upon the literature and the findings of this study, the following conclusions were made:

1. Rollover protective structures (ROPS) are the most effective strategy in saving lives lost due to tractor overturns.
2. All tractor passengers run over were children.

3. Narrow front tractors were those involved in the greatest proportion of fatalities.

4. Tractor and motor-vehicle collisions were the third highest category of tractor-related deaths.

5. Tractor-related fatalities can be reduced by 80% over a five year period.

Recommendations for Action

Based upon the findings and conclusions of this study, the following recommendations were made:

1. An aggressive plan of action be implemented to eliminate 80% of tractor-related deaths in a short amount of time (5 years).

2. The results of this study need to be disseminated to proper policy groups and people responsible for initiating and promoting agricultural safety intervention strategies.

3. Community and public support for a farmer’s health and safety must be encouraged and facilitated.

4. Policies directed towards discussing issues involving liability claims to manufacturers need to be developed.

5. Agricultural safety issues must be an integral part of agricultural programs and events.

6. The Iowa Department of Public Health’s surveillance of agricultural injuries program (SPRAINS) should be maintained.
Implications

Implications to engineering

The implications to engineering in tractor accident prevention and/or operator protection identified include:

1. Older tractors without ROPS are widely used and will continue to be used for quite some time. Retrofit ROPS need to be promoted.

2. The engineering challenge for safety lies in developing affordable methods of retrofitting older equipment with features that protect the operator and promote safe equipment operation. These include improved seating, lighting, turn signals, and ROPS/operator restraint packages.

3. Alternative types of operator restraint systems need to be investigated. Use of the seat belt has not been accepted by farmers.

Implications to education

The implications to education in tractor accident prevention and/or operator protection identified include:

1. Tractor owners and operators need to be informed of the life-saving protection provided by a ROPS.

2. Owners of tractors without ROPS need to be informed of the availability, accessibility, and cost information for retrofitting ROPS on these tractors.

3. Reminders need to continuously be publicized about the risk to extra riders on tractors. These can be targeted towards both the operators and the potential riders (usually children). Riders are also exposed to dusts, chemicals, vibrations, and noise.

4. Safe tractor operation needs to be taught through tractor operator training courses.
5. Tractor safety education needs to be aimed at different target audiences for different purposes. Examples include: educating children to stay away from operating equipment and to not request rides on tractors; the farm-wife to ensure the children do not ride on equipment and to encourage the use of protective equipment; tractor operators with training in safe tractor operation as well as the use of ROPS; the community for the purpose of making safety options available and accessible for the farmer. Tractor operator training can also be taught to farm-wives who may have to operate a tractor in an emergency or hazardous situation, e.g., when a tractor becomes stuck.

6. Agricultural safety involves curriculum and program development needs for all educational levels. This includes children, even prior to school age. Educational efforts need to be implemented in both formal and non-formal settings, for people of all ages.

7. Agricultural safety needs to be taught at the college level to those students who anticipate working with farmers or for farmers (e.g., educators, agri-business); as well as to engineering students who may design farm equipment.

8. Activities encouraging and promoting the involvement and participation of the learner need to be developed and used. Examples include farm safety day camps and hazard identification type projects.

9. Farmers and farm families need to be knowledgeable of the hazards as well as knowledgeable of safer alternatives and options.

**Implications for regulations**

The implications for regulations in tractor accident prevention and/or operator protection identified include:
1. The endorsement and promotion of refurbishing older equipment with safety items, including; lighting, shields, and ROPS, through standards and recommendations by agencies such as ASAE and NIFS.

2. The establishment and enforcement of regulating tractor operation on public roadways. This includes lighting, marking, and enforcing operator rules that apply to other vehicle operators on public roadways, e.g., age and OWI.

3. Extra riders on tractors can be prohibited on public roadways.

Implications for community involvement

Strategies for community involvement in tractor accident prevention and/or operator protection identified include:

1. Safety equipment needs to be available, accessible, and affordable in order to be used. Provisions also need to be provided for the proper installation of such devices.

2. Promotion and encouragement of safe behavior on a community-wide basis. An example includes endorsing the policy of no extra riders on tractors used in parades.

3. Development of community based safety programs such as those offered through the Iowa Health and Safety Services Program (IA-HASSP), local extension, agribusinesses, community colleges, et al.

4. Identification of local resources that are available to facilitate the implementation of intervention strategies.
Recommendations for Further Research

Recommendations for further research include:

1. More analysis of non-fatal injury data and the seriousness of injury should be conducted in order to evaluate the full impact of the injury. There is a large difference between an injury that requires stitches on a finger, and an injury that results in a permanent disability.

2. It would be beneficial to determine the number of tractors that were involved in an overturn in which there were no injuries. At present, there is no way of determining this, except through random surveys. A survey of equipment dealers and tractor repair shops may be a potential source for this information. This could be used in developing a more accurate method to identify tractors at most risk to be in an overturn fatality.

3. Technological solutions for adequate and proper lighting and marking, seating packages, and effective operator constraint systems, need to be analyzed. These need to be considered for new equipment as well as for retrofitting older equipment.
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... to my children, Ann and Philip
... to the Wednesday night ceramics group, Doris Deen, Diana Faulkner, and Deb Franklin at Central City, Iowa for their continuous harassment and the gift of laughter.

... to Cheryl Smith for her patience with listening to the latest trials and tribulations of graduate school.

... to Dee VanDePol for her assistance with the typing and production of this thesis.
APPENDIX A: NIFS RESOLUTIONS AND MINNESOTA LAW
SAFETY EQUIPMENT ON FARM TRACTORS

Sec. 24. [325F.6670] [EQUIPMENT REQUIRED AT TIME OF SALE.]

(a) No farm equipment dealer or other seller required to collect an excise tax under section 297A.02 may sell a farm tractor as defined in section 325F.6651, subdivision 2, unless, at the time of sale, the tractor is equipped with safety equipment as provided in paragraphs (b) and (c).

(b) If originally provided by the manufacturer, the farm tractor must have

(1) power-take-off shields; and

(2) road transport lighting and reflector systems.

(c) Whether or not originally provided by the manufacturer, the farm tractor must have a slow-moving vehicle sign displayed in accordance with section 169.522.
RESOLUTION

WHEREAS a significant portion of fatal farm injuries result from tractor overturns, and

WHEREAS ROPS and seatbelts are very effective in preventing these fatal injuries, and

WHEREAS a portion of the tractors manufactured since 1969 are not equipped with ROPS, and

WHEREAS ROPS are generally available for tractors manufactured since 1969, and

WHEREAS some of these tractors are traded in through farm equipment dealers annually;

BE IT RESOLVED that NIFS encourages farm equipment dealers to install ROPS and seatbelts on tractors manufactured after 1969 before these tractors are offered for resale, and

BE IT FURTHER RESOLVED that the President of NIFS should communicate this resolution to farm equipment dealers associations, farm equipment manufacturers associations and groups working to establish a national agricultural safety and health agenda.

Presented by the Resolutions Committee as submitted by the Tractor and Machinery Committee and adopted by the membership of the National Institute for Farm Safety, Inc. on June 20, 1991, in Jackson, Mississippi.
RESOLUTION

WHEREAS a portion of the injuries on farms attributed to the operation of farm equipment are due to missing guards, shields, safety signs and other such safety devices that were originally installed on the equipment, and

WHEREAS these injuries could be reduced if these guards, shields, safety signs, and safety devices were replaced;

BE IT RESOLVED that NIFS encourages farm equipment dealers to refurbish used farm equipment to its original or an improved safety condition prior to offering this equipment for resale, and

FURTHERMORE the President of NIFS should communicate this resolution to farm equipment dealer associations, farm equipment manufacturers associations, and groups working to establish a national agricultural safety and health agenda.

Presented by the Resolutions Committee as submitted by the Tractor and Machinery Committee and adopted, as amended, by the membership of the National Institute for Farm Safety, Inc. on June 20, 1991, in Jackson, Mississippi.
APPENDIX B: EXAMPLES FROM ROPS DIRECTORY
**Ordering Procedure:** Custom Products sells through the major tractor lines' dealer networks. Customers should contact their local implement dealers.

Custom Products states their ROPS cabs comply with applicable OSHA standards when properly installed.

<table>
<thead>
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<th>Tractor Manufacturer</th>
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<th>ROPS Model and Type</th>
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**Notes**
- Cabs come with seat belts.
- Lists of standard and optional equipment are available from the company.
Ford NeHolland, Inc.
500 Diller Avenue
New Holland, PA 17557
(717) 355-1121

Ordering Procedure: Ford NeHolland sells through dealers. Prospective customers should contact a Ford NeHolland dealer.

Ford NeHolland states their ROPS comply with applicable OSHA and SAE standards when properly installed.

Series 794 Roll Over Protection System

<table>
<thead>
<tr>
<th>Tractor Manufacturer</th>
<th>Tractor Model</th>
<th>Seat Option on Tractor</th>
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</table>

Footnotes
1 - Refer to dealer parts book
APPENDIX C: FOLLOW UP QUESTIONNAIRE
# IOWA FARM INJURY REPORT FORM

**Type or print answers to all questions below:**

<table>
<thead>
<tr>
<th>Reporting Clinic/Hospital:</th>
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<tbody>
<tr>
<td>Person Completing Report:</td>
<td></td>
</tr>
<tr>
<td>Position/Title:</td>
<td></td>
</tr>
<tr>
<td>Phone: ( )</td>
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<tr>
<td>Date form completed: / /</td>
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</tr>
</tbody>
</table>

**PATIENT DEMOGRAPHICS**

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>Last</th>
<th>First</th>
<th>M.I.</th>
<th>If child, name of parent/guardian:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address: Street/R.R.#</td>
<td>City</td>
<td>County</td>
<td>State</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>Age</td>
<td>Date of Birth: / /</td>
<td>Res Phone No: ( )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PATIENT BACKGROUND:** (Check one)

- Farmer full time
- Farmer full time & part time other employment
- Farmer part time & full time other employment
- Non farm resident / visitor
- Farm family member
- Farm service person
- Farm employee/worker
- Off farm occupation or industry:

**INJURY INFORMATION**

| Date of Injury: / / | Time of Injury: : AM / PM |  |
| City/County where injury occurred: | Where did accident happen? (see list on back of form) |  |
| Injury Diagnosis/Description: (include ICD-9 Codes if available) |  |
| Severity: | Estimated time off work: (Check one) |
| Hospitalized? | Transferred? |
| Yes | No | Yes | No |
| Fatal? |  |
| Yes | No |
| Less than 1 week | 4 weeks to 6 months |
| 1 to 4 weeks | 6 months to indefinite |
| Intentionality: |  |
| Self inflicted | Assaultive |
| Not applicable |  |
| Was the injury: |  |
| Recreation? | Yes | No |
| Farm Business? | Yes | No |
| Alcohol related? | Yes | No |

TELEPHONE REPORTS: 1-800-779-7559

Check if you need more forms
DEFINITIONS

Agriculturally related injury:
A non-household injury incurred on the farm by any farmer, farm worker, farm family member, or other individual, or any off the farm injury incurred by a farmer, farm worker, or farm family member in the course of handling, producing, processing, transporting, or warehousing farm commodities. Reportable injuries would include those incurred by non-farmers who are on the farm environs for a wide variety of purposes: visiting, hunting, swimming, and other recreational activities.

Where did accident happen:
Barn, barnyard, feedlot, driveway, farm building (not house), field (cropland), highway (state or federal), ag industry, warehouse, land (pasture, range, woods), lagoon, manure pit, pond, pool, stream, river, road (county or local), or other (specify).

Injury causing event:
Actual event that induced injury, i.e.; tractor roll-over, caught in power take off, unloading grain wagon, hazardous material spill, collision, or chopping wood.

Please make comments on needed changes of this form:

Please mail reports to:
IOWA DEPARTMENT of PUBLIC HEALTH
321 East 12th Street
Lucas State Office Building 1st Floor
Des Moines, IA 50319-0075
GENERAL PROFILE

ID# _______________  County # _______________

Date of Event: ______/____/____  Patient Name: __________________________

1) PATIENT BACKGROUND:
   ___ Farmer full time
   ___ Farmer full time & part time
   ___ Farmer part time & full time
   ___ other employment
   ___ Non farm resident/visitor
   ___ Farm family member
   ___ Farm service person
   ___ Farm employee/worker

2) AGE: ___ Yrs  3) SEX: ___ Male  ___ Female

4) WAS INJURY: ___ Work related  ___ Leisure related

5) MONTH OF ACCIDENT: __________________________

6) DAY OF THE WEEK: __________________________

7) TIME OF ACCIDENT: ___:___ AM/PM

8) DATE AND TIME PATIENT RECEIVED MEDICAL TREATMENT: __________________________

9A) WAS ACCIDENT WITNESSED? ___ Yes  ___ No

9B) HOW LONG BEFORE INJURED DISCOVERED __________________________

10) TYPE OF INJURY:
    ___ Amputation  ___ Eye injury
    ___ Asphyxiation  ___ Mangled
    ___ Bruised  ___ Pinched
    ___ Burn  ___ Puncture
    ___ Fracture  ___ Sprain
    ___ Laceration  ___ Multiple
    ___ Other __________________________

11) ANY PERMANENT DISABILITY?  ___ Yes  ___ No

12) PART OF BODYInvolved:
    ___ Arm  ___ Hand
    ___ Back  ___ Head
    ___ Chest  ___ Leg
    ___ Eye  ___ Neck
    ___ Finger  ___ Shoulder
    ___ Foot  ___ Toe
    ___ Genital  ___ Trunk
    ___ Multiple (specify) __________________________
    ___ Other __________________________

13) HOW DID INJURY OCCUR?
    ___ Caught body in object
    ___ Caught body between objects
    ___ Caught body under object
    ___ Struck against object
    ___ Struck by object
    ___ Fall, same level
    ___ Fall, different level
    ___ Fall, unknown
    ___ Contact with electrical current
    ___ Contact with fire or hot object
    ___ Contact with toxic substance
    ___ Over exertion (strain, exhausted)
    ___ Inhaling gas or vapor
    ___ Other __________________________

14A) WHERE WAS PERSON TREATED?
    ___ Clinic
    ___ Doctors office
    ___ Hospital, outpatient
    ___ Hospital, admitted

14B) IF HOSPITALIZED, HOW LONG?
    ___ Months  ___ Days

14C) DID HOSPITALIZATION REQUIRE SURGERY?  ___ Yes  ___ No
    If yes, describe: __________________________

14D) PROFESSIONAL TREATMENT REQUIRED:
    ___ One time  ___ Three times
    ___ Two times  ___ Four times
    ___ Five or more times (#___)

15) COST ESTIMATION OF EXPENSES YOU HAD AS A RESULT OF YOUR INJURY
    A) Hospitalization$ __________________________
    B) Physician Visits$ __________________________
    C) Prescription Drugs$ __________________________
    D) Rehabilitation __________________________
       WHY ___ Medical/Surgical
       ___ Mental/Emotional
       ___ Rehabilitation

    E) Outpatient Physical Therapy __________________________
    F) Ambulance/Helicopter Transport __________________________
    G) Attendant Care __________________________
    H) Vocational Rehabilitation __________________________
    I) Person(s) to do farm work during healing period __________________________
    J) Sold/Lost farm ___ acres __________________________
    K) Other __________________________

588-275R-1
17) SCENE OF ACCIDENT:

17A) WEATHER CONDITIONS:

1) Temperature (degrees):
   - 0 or below
   - 1 to 32
   - 33 to 50
   - 51 to 85
   - 86 to 100
   - over 100
   - Rain
   - Snow
   - Threatening

2) Precipitation:
   - Clear
   - Rain
   - Snow
   - Threatening

3) Wind:
   - Calm
   - Light breeze
   - 10 to 25 mph
   - 26 to 40 mph
   - Over 40 mph

17B) GENERAL LOCATION:

• Ag industry/warehouse
• Barn
• Barnyard / Feedlot
• Driveway
• Farm building, other
• Field (cropland)
• Highway, state or federal
• Land (pasture, range, woods)
• Lagoon, manure pit
• Pond, pool, stream, river
• Road, county or local
• Other

17C) SURFACE CONDITION:

• Dry
• Icy
• Muddy
• Wet
• Straw, hay, sawdust, etc.
• Other

17D) SURFACE TYPE:

• Asphalt
• Brick
• Concrete
• Metal
• Soil (bare dirt, clay, sand)
• Vegetation covered
• Wood
• Other

17E) LIGHT CONDITIONS:

• Artificial light, good
• Artificial light, poor
• Daylight
• Dark
• Dawn or dusk

18) ITEM INVOLVED:

• Agricultural machinery
  (except tractors)
• Animal
• Another person
• Chemical
• Electrical power
• Firearms
• Gas or vapor
• Hand tool
• Power tool
• Tractor
• Truck
• Auto, bus, other vehicle
• Power-take-off
• Powered lawn &/or garden equipment. Also snowmobile or other recreational equipment
• Other

19) APPROXIMATE TIME VICTIM WAS WITH
   "ITEM INVOLVED" ON DAY OF ACCIDENT:

• One hour or less
• 2 to 4 hours
• 5 to 8 hours
• Over 12 hours

20) ESTIMATE EXPERIENCE WITH THE
    "ITEM INVOLVED":

• Years
• Months
• Days

21) GENERAL INFORMATION:

21A) MAJOR TYPE OF AGRICULTURAL
     OPERATION: Check all that apply

• Corn
• Oats
• Soybeans
• Wheat
• Hay
• Fruit
• Truck crops
• Nursery
• Other field crops
• Other

21B) ACREAGE IN AGRICULTURAL
     OPERATION:

• (Fill in actual acreage)

21C) DO YOU PRODUCE $1,000 OR MORE OF
     AGRICULTURAL PRODUCTS ANNUALLY?

• Yes
• No
# SPRAINS REPORT FORM

## AGRICULTURAL TRACTORS

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<th>County</th>
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</table>

### Case of event: ________________  
Patient Name: ________________________

### 1) TRACTOR IDENTIFICATION:
- **MAKE:**
- **MODEL:**
- **FUEL TYPE:**
  - Gas
  - Diesel
  - LP

### 2) TYPE OF TRACTOR INVOLVED:
- Tricycle
- Wide front axle
- Front wheel assist
- Hi-crop
- Crawler
- 4-wheel-drive, articulated

### 3) APPROXIMATE AGE OF TRACTOR:
- One year or less
- 2 to 5 years
- 6 to 10 years
- Over 10 years

### 4) INDICATE TYPE OF ACCIDENT:
- Collision, from the side
- Collision, head-on
- Collision, rear
- Equipment failure
- Fall
- Fire
- Overturn, backward
- Overturn, sideways
- PTO
- Run over
- Other ____________

### 5) WHEEL SPACING AT TIME OF ACCIDENT:
- Narrow
- Normal or mid-setting
- Wide or extended

### 6) TRACTOR USE AT TIME OF ACCIDENT:
- Freeing mired equipment
- Harvesting, tillage
- Herding cattle/livestock
- Loading, unloading
- Parked, stationary—not running
- Planting, sowing
- Runaway or coasting (w/o driver)
- Stationary (belt or PTO on)
- Stuck
- Traveling to or from field
- Unknown
- Other ____________

### 7) IF TRACTOR OVER-TURN, INDICATE DEGREES OF ROLL:
- 90
- 180
- Over 360
- 270

### 8) CHECK THE CONDITION THAT WAS THE INITIAL CAUSE OF THE ACCIDENT EVENT:
- Crossing, slope
- Damaged PTO guard or shield
- Faulty brakes
- Going down hill
- Going up hill
- Guard not provided
- Guard removed
- Hidden object—struck it
- Hitched above drawbar
- Struck hole or rough ground
- Slipped into open ditch
- By-pass starting
- Repairing/modifying
- Other ____________

### 9) IDENTIFY THE ACT PERMITTING THE ACCIDENTAL INJURY:
- Disobeyed traffic rules
- Driving too fast for conditions
- Failed to disengage PTO engine before dismounting
- Failed to lock brakes or transmission before dismounting
- Failed to use protective equip.
- Failed to engage clutch slowly
- Failed to wear safe attire
- Horseplay
- Jumped
- Lack of front or rear weights
- Moving tractor w/loader high
- Permitted extra rider
- Permitted hitching to other
- Reaching (over, under, into)
- Smoking while refueling
- Turning at high speed
- Overloading
- Unknown
- Other ____________
10) SPECIFIC SCENE OF ACCIDENT:
   - Barn
   - Bridge
   - Cattle shed
   - Driveway, lane
   - Feedlot
   - Grain field
   - Hay field
   - Highway
   - Pasture
   - Shop or machine shed
   - Woods
   - Gravel road
   - Other

11) CHECK EACH COMPONENT ON TRACTOR AT TIME OF ACCIDENT:
   - Cab
   - Cab w/Rollover protection structure & seat belt
   - Dual wheels
   - Fenders
   - Flashing light(s)
   - Front end weights
   - Front wheel drive
   - Front wheel weights
   - Head lights
   - Hydraulic brakes
   - Power steering
   - PTO shield
   - Protective frame w/seat belt
   - Reflectors
   - Rearview mirror(s)
   - Rear wheel weights
   - Safety starting switch
   - SMV emblem
   - Tail light(s)
   - Tires filled w/liquid
   - Weather shield

12) SEAT BELT IN USE AT TIME OF ACCIDENT:
   - Yes
   - No

13) WERE BRAKES LOCKED TOGETHER?
   - Yes
   - No

14) CONDITION OF DRIVING SURFACE:
   - Dry
   - Muddy
   - Wet grass
   - Snow covered
   - Ice
   - Frozen
   - Cement/blacktop
   - Gravel

15) AWARENESS OF HAZARD/DANGER AT TIME:
   - Fully aware
   - Some what aware
   - Not aware

16) CHECK APPROPRIATE BOX:
   - Able to hear well. No problems
   - Hearing affected somewhat by (fill in)
   - Very poor hearing due to

17) HAVE YOU ATTENDED TRACTOR OPERATOR COURSE
   - Yes
   - No

18) YEARS DRIVING TRACTORS:
   - Less than 6 mo
   - Less than 1 yr
   - 1-2 yrs
   - 2-3 yrs
   - 4-5 yrs
   - 5-10 yrs
   - 10-20 yrs
   - Over 20 yrs

19) LENGTH OF TIME YOU'VE DRIVEN THE TRACTOR INVOLVED IN INJURY

20) OTHER TRACTORS AVAILABLE ON FARM
   - MAKE
   - MODEL
   - AGE
   - FUEL TYPE
   - LIST BELOW:
   1.
   2.
   3.
   4.
   5.

21) PLEASE IDENTIFY YOUR RECOMMENDATIONS FOR PREVENTION OF INJURY DUE TO TRACTOR ACCIDENT (USE BACK IF NECESSARY)
APPENDIX D: INDIVIDUAL TRACTOR-RELATED FATALITIES DESCRIBED (IOWA 1988-1990)
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<th>Location</th>
<th>OT</th>
<th>Tractor Type</th>
<th>Tractor Age</th>
<th>Victim OP or OT</th>
<th>Victim Age</th>
<th>ROPS</th>
<th>Comments</th>
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<td>65</td>
<td>N</td>
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<tr>
<td>SC</td>
<td>3</td>
<td>OT in field while doing chores, driving across slope</td>
<td>F</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td>41</td>
<td>N</td>
<td>Rolled 2 1/2 time Female</td>
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<td>NE</td>
<td>6</td>
<td>Pulling hay wagon on gravel road, U-turn &amp; OT</td>
<td>R</td>
<td>S</td>
<td>-</td>
<td>-</td>
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<td>47</td>
<td>N</td>
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<td>Riding tractor being towed by pickup, no power brakes or steering, OT</td>
<td>R</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td>70</td>
<td>Y</td>
<td></td>
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<tr>
<td>NW</td>
<td>10</td>
<td>Car hit tractor head-on car crossed center line</td>
<td>R</td>
<td>-</td>
<td>W</td>
<td>6-10</td>
<td>T</td>
<td>74</td>
<td>N</td>
<td>Pulling 2 wagons of corn, tractor split in two</td>
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<td>NC</td>
<td>5</td>
<td>Crushed by SKL</td>
<td>F</td>
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<td>6-10</td>
<td>P</td>
<td>62</td>
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<td>Pinned between arms while pulling stump</td>
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<td>WC</td>
<td>2</td>
<td>Spreading straw on icy bridge, OT</td>
<td>F</td>
<td>S</td>
<td>W</td>
<td>6-10</td>
<td>P</td>
<td>74</td>
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<td>NW</td>
<td>10</td>
<td>Backed too close to edge and rear OT into creek</td>
<td>F</td>
<td>R</td>
<td>SKL</td>
<td>&gt;10</td>
<td>P</td>
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<td>NW</td>
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<td>Doing dirt work, too close to edge of road and OT</td>
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<td>-</td>
<td>P</td>
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<td>SC</td>
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<td>Mowing on backside of steep terraces, OT</td>
<td>F</td>
<td>R or S</td>
<td>-</td>
<td>P</td>
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<td>Discing steep hillside, OT</td>
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<td>NE</td>
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<td>Fell off going downhill runover</td>
<td>F</td>
<td>-</td>
<td>W</td>
<td>P</td>
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<td>NE</td>
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<td>Repairing SKL, bucket fell on head</td>
<td>Yard</td>
<td>-</td>
<td>SKL</td>
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<td>57</td>
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<td>Hit large round bale in the field, OT</td>
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<td>W</td>
<td>P</td>
<td>26</td>
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<td>NE</td>
<td>5</td>
<td>Went into ditch off county road, OT</td>
<td>R</td>
<td>S</td>
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<td>P</td>
<td>67</td>
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<td>1</td>
<td>Icy hillside, slid down ravine, OT</td>
<td>F</td>
<td>S</td>
<td>Track</td>
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<td>SE</td>
<td>6</td>
<td>Pulling load of hay through field when tractor OT</td>
<td>F</td>
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<td>P</td>
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<td>NE</td>
<td>1</td>
<td>Moving large rd bale of cornstalks w(SKL, bale rolled on machine &amp; OP</td>
<td>F</td>
<td>SKL</td>
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<td>6</td>
<td>Ran stop sign on gravel rd turning 90° corner, slid into ditch, OT</td>
<td>R</td>
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<td>CRD Month</td>
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<td>Tractor Type</td>
<td>Tractor Age</td>
<td>Victim OP or OT</td>
<td>Victim Age</td>
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<td>Lost control pulling two hayracks, went into ditch, OT and pinned</td>
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<td>SW 1</td>
<td>Slid down embankment &amp; OT (night, January)</td>
<td>F</td>
<td>S</td>
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<td>-</td>
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<td>71</td>
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<td>C 5</td>
<td>Struck fence in field</td>
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<td>64</td>
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<tr>
<td>C 11</td>
<td>OT in ditch and pinned</td>
<td>R</td>
<td>S</td>
<td>-</td>
<td>&gt;10</td>
<td>P</td>
<td>29</td>
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<tr>
<td>NC 9</td>
<td>Backing tractor to hook to trailer, fell, pinned between tractor/trailer</td>
<td>Yard</td>
<td></td>
<td>-</td>
<td>-</td>
<td>P</td>
<td>26</td>
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<tr>
<td>SE 10</td>
<td>Working on incline, OT &amp; pinned, pulling wagons</td>
<td>F</td>
<td>R</td>
<td>-</td>
<td>&gt;10</td>
<td>P</td>
<td>70</td>
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<td>NE 3</td>
<td>Pulling logs uphill, OT, muddy</td>
<td>F</td>
<td>R</td>
<td>W</td>
<td>&gt;10</td>
<td>P</td>
<td>65</td>
<td>N</td>
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<tr>
<td>NE 1</td>
<td>On road shoulder, OT in ditch, icy conditions, too close to edge, pulling a wagon</td>
<td>R</td>
<td>S</td>
<td>W</td>
<td>&gt;10</td>
<td>P</td>
<td>33</td>
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<tr>
<td>EC 8</td>
<td>Tractor turned left while car passing</td>
<td>R</td>
<td>S</td>
<td>-</td>
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<td>P</td>
<td>61</td>
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<td>SE 12</td>
<td>To cut wood, slipped into ditch, OT and pinned</td>
<td>F</td>
<td>S</td>
<td>-</td>
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<td>EC 7</td>
<td>Motor vehicle and tractor, met at crest of hill, car lost control swerving to avoid, hit broadside by tractor</td>
<td>R</td>
<td>-</td>
<td>-</td>
<td>T</td>
<td>20</td>
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<tr>
<td>NC 5</td>
<td>Using loader to fill in ditch, OT and pinned</td>
<td>- S</td>
<td>-</td>
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<td>P</td>
<td>61 N</td>
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<tr>
<td>NC 7</td>
<td>Leveling field lane, OT in creek &amp; pinned</td>
<td>F S</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td>50 N</td>
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<tr>
<td>NC 9</td>
<td>Tractor pulling wagon, turned left while motor vehicle passing</td>
<td>R</td>
<td>-</td>
<td>-</td>
<td>T</td>
<td>61 -</td>
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<tr>
<td>EC 7</td>
<td>Backing tractor off trailer, OT</td>
<td>Yard</td>
<td>-</td>
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<td>P</td>
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<tr>
<td>EC 9</td>
<td>Riding on tractor with father, fell off and runover</td>
<td>R</td>
<td>-</td>
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<td>P</td>
<td>6 Female</td>
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<tr>
<td>EC 2</td>
<td>Too close to creek bank; track tractor, OT and pinned</td>
<td>F S</td>
<td>Track</td>
<td>-</td>
<td>P</td>
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<td>SE 8</td>
<td>Working on track type on the ground, it started and ran over</td>
<td>Yard</td>
<td>Track</td>
<td>&gt;10</td>
<td>P</td>
<td>60 N/A</td>
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<tr>
<td>SE 5</td>
<td>Thrown from tractor and run over</td>
<td>F</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
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<tr>
<td>SW 7</td>
<td>Slid off muddy road shoulder, OT</td>
<td>R S N</td>
<td>&gt;10</td>
<td>P</td>
<td>50 N</td>
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<td>CRD</td>
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<td>Description</td>
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<td>OT</td>
<td>Tractor Type</td>
<td>Tractor Age</td>
<td>Victim OP or OT</td>
<td>Victim Age</td>
<td>ROPS</td>
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<td>EC</td>
<td>12</td>
<td>Pulling hay wagon up icy hill with track tractor, lost traction, slid downhill into gully, OT and pinned</td>
<td>F</td>
<td>S</td>
<td>Track</td>
<td>-</td>
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<td>EC</td>
<td>4</td>
<td>Drove off road, OT and pinned</td>
<td>R</td>
<td>S</td>
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<td>53</td>
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<td>NW</td>
<td>5</td>
<td>Front end hit furrow, OT</td>
<td>F</td>
<td>R</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>60</td>
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<tr>
<td>C</td>
<td>7</td>
<td>Fell off end-loader and run over</td>
<td>-</td>
<td>E</td>
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<td>May or may not have been farm</td>
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<td>WC</td>
<td>6</td>
<td>Towing trailer w/pigs; crossed unmarked RR xing and hit by train</td>
<td>R</td>
<td>W</td>
<td>6-10</td>
<td>P</td>
<td>23</td>
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<td>Fatality due to train impact &amp; not the result of OT</td>
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<td>NW</td>
<td>9</td>
<td>Off tractor to hitch to silage wagon; in neutral on incline, tractor moved and pinned between wagon and tractor</td>
<td>Yard</td>
<td>W</td>
<td>&gt;10</td>
<td>P</td>
<td>40</td>
<td>Y</td>
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<td>NW</td>
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<td>Pulling wagon on muddy dirt road, slid off road, hit culvert and OT</td>
<td>R</td>
<td>S</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>81</td>
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<td>NW</td>
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<td>Tractor moved, pinned between combine head and tractor</td>
<td>Yard</td>
<td>W</td>
<td>&lt;1</td>
<td>P</td>
<td>33</td>
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<td>SE 8</td>
<td>Chasing bull in muddy clay; OT and pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>38  Y</td>
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<td>SE 7</td>
<td>Pinned between wheels of skid loader</td>
<td>Drive</td>
<td>SKL</td>
<td>&gt;10</td>
<td>P</td>
<td>65</td>
<td>Y</td>
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<tr>
<td>SE 8</td>
<td>OT and pinned on incline</td>
<td>F</td>
<td>R</td>
<td>-</td>
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<td>P</td>
<td>42  -</td>
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<td>SE 7</td>
<td>Tractor pulling 3 wagons pulled into path of vehicle</td>
<td>R</td>
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<td>NC 8</td>
<td>Hauling LP tank, load may have shifted, OT and pinned</td>
<td>Yard</td>
<td>S</td>
<td>-</td>
<td>-</td>
<td>P</td>
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<td>WC 9</td>
<td>By-pass starting</td>
<td>Shed</td>
<td>-</td>
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<td>T</td>
<td>52</td>
<td>N/A Operator injured</td>
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<td>WC 8</td>
<td>Grading dirt, pinned under tractor</td>
<td>Field</td>
<td>S</td>
<td>-</td>
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<td>P</td>
<td>67  -</td>
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<td>SC 2</td>
<td>Grinding feed, dark, grinder attached, backed over wife</td>
<td>Yard</td>
<td>-</td>
<td>-</td>
<td>T</td>
<td>50</td>
<td>N/A Female</td>
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<td>NW 5</td>
<td>Train hit tractor; tractor enroute to field early am, sun in eyes; brush by track</td>
<td>R</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>51</td>
<td>N</td>
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<td>SC 8</td>
<td>Tractor Acc</td>
<td>F</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>57</td>
<td>N  Hay field</td>
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<td>SC 8</td>
<td>Passenger on tractor while uncle raking hay fell off, runover</td>
<td>F</td>
<td>N</td>
<td>&gt;10</td>
<td>T</td>
<td>8</td>
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<td>CRD Month</td>
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<td>OT Type</td>
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<tr>
<td>NW 1</td>
<td>Washing SKL, pinned between bucket and SKL</td>
<td>Yard</td>
<td>SKL</td>
<td>-</td>
<td>P</td>
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<td>SC 5</td>
<td>Hauling dirt w/tractor loader; tractor OT and pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt; 10</td>
<td>P</td>
<td>84</td>
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<td>SC 8</td>
<td>Baling hay using large round baler, tractor OT and pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt; 10</td>
<td>P</td>
<td>64</td>
<td>N</td>
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<tr>
<td>NE 6</td>
<td>Parked tractor on incline, tractor moved back and ran over operator</td>
<td>F</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td>70</td>
<td>N/A</td>
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<tr>
<td>NE 8</td>
<td>Mowing, hit tree, fell off tractor, pinned</td>
<td>F</td>
<td>N</td>
<td>&gt; 10</td>
<td>P</td>
<td>47</td>
<td>N</td>
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<tr>
<td>EC 4</td>
<td>Son riding w/father cleaning ditches, tractor OT, father clear, son pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt; 10</td>
<td>T</td>
<td>5</td>
<td>N</td>
<td></td>
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</tr>
<tr>
<td>EC 5</td>
<td>Tractor turned left, hit by oncoming vehicle</td>
<td>R</td>
<td>FWA</td>
<td>6-10</td>
<td>T</td>
<td>54</td>
<td>Y</td>
<td>2 females in car killed 1 car occupant - comatose (17 yr old operator not injured; however, permanent psychologic damage)</td>
<td></td>
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</tr>
<tr>
<td>WC 7</td>
<td>Moving equipment w/front</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt; 10</td>
<td>P</td>
<td>71</td>
<td>N</td>
<td></td>
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<tr>
<td>Code</td>
<td>Incident</td>
<td>Age</td>
<td>Gender</td>
<td>Injury</td>
<td>Cause</td>
<td>Status</td>
<td>Alcohol</td>
<td>Notes</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>WC  5</td>
<td>Tractor OT, passenger fatality, operator injury</td>
<td>&gt;10</td>
<td>F</td>
<td>S</td>
<td>W</td>
<td>T</td>
<td>15</td>
<td>N Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC 10</td>
<td>Thrown through cab-window runover</td>
<td>&gt;10</td>
<td>F</td>
<td>N</td>
<td>P</td>
<td>85</td>
<td>Y</td>
<td>Seat belt not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW  5</td>
<td>OT in field</td>
<td>&gt;10</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>P</td>
<td>54</td>
<td>N Alcohol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW  4</td>
<td>With front end loader, OT and pinned</td>
<td>&gt;10</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>P</td>
<td>59</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC  7</td>
<td>OT</td>
<td>&gt;10</td>
<td>F</td>
<td>R</td>
<td>W</td>
<td>P</td>
<td>82</td>
<td>N</td>
<td></td>
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<tr>
<td>WC 11</td>
<td>SKL OT and pinned, Pulling it w/another tractor to start it</td>
<td>SKL 6-10</td>
<td>Drive</td>
<td>SKL</td>
<td>P</td>
<td>59</td>
<td>Y</td>
<td></td>
<td></td>
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<tr>
<td>SW  6</td>
<td>Tractor struck from rear by delivert truck</td>
<td>&gt;10</td>
<td>R</td>
<td>N</td>
<td>P</td>
<td>75</td>
<td>N</td>
<td>Did not fall off; died of internal injuries</td>
<td></td>
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<tr>
<td>SW  8</td>
<td>Mowing weeds in ditch along gravel road; wheel hit stump and OT</td>
<td>&gt;10</td>
<td>R</td>
<td>S</td>
<td>N</td>
<td>P</td>
<td>47</td>
<td>N</td>
<td></td>
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<tr>
<td>NW  9</td>
<td>Driving tractor on gravel road, went into ditch and OT</td>
<td>&gt;10</td>
<td>R</td>
<td>S</td>
<td>W</td>
<td>P</td>
<td>20</td>
<td>N</td>
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</tr>
<tr>
<td>NC  8</td>
<td>Tractor OT in ditch while driving along gravel road</td>
<td>&gt;10</td>
<td>R</td>
<td>S</td>
<td>N</td>
<td>P</td>
<td>73</td>
<td>N</td>
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<tr>
<td>NE  6</td>
<td>Passenger fell out of tractor cab</td>
<td>&gt;10</td>
<td>F</td>
<td>W</td>
<td>T</td>
<td>3</td>
<td>Y</td>
<td>Female</td>
<td></td>
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<tr>
<td>CRD Month</td>
<td>Description</td>
<td>Location R/F</td>
<td>OT S/R</td>
<td>Tractor Type</td>
<td>Tractor Age</td>
<td>Victim OP or OT</td>
<td>Victim Age</td>
<td>ROPS</td>
<td>Comments</td>
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<td>-----------</td>
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<td></td>
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<tr>
<td>NE 11</td>
<td>Plowing field, tractor OT and pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>68</td>
<td>N</td>
<td></td>
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<tr>
<td>NE 10</td>
<td>Hired man under tractor doing repairs, operator started &amp; drove tractor over</td>
<td>Yard</td>
<td></td>
<td>4-WD ART</td>
<td>2-5</td>
<td>T</td>
<td>53</td>
<td>Y</td>
<td></td>
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<tr>
<td>NE 12</td>
<td>Freeing stuck vehicles; icy gravel road, 2 a.m., OT</td>
<td>R</td>
<td>S</td>
<td>FWA</td>
<td>2-5</td>
<td>P</td>
<td>25</td>
<td>N</td>
<td>Alcohol</td>
<td></td>
</tr>
<tr>
<td>NE 9</td>
<td>Moving large round bale; rolled down loader arms crushed operator</td>
<td>F</td>
<td></td>
<td>W</td>
<td>6-10</td>
<td>P</td>
<td>84</td>
<td>N</td>
<td></td>
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<tr>
<td>SE 12</td>
<td>Pinned between arm and cab of SKL</td>
<td>Yard</td>
<td></td>
<td>SKL</td>
<td>-</td>
<td>P</td>
<td>19</td>
<td>N</td>
<td></td>
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<tr>
<td>NE 3</td>
<td>Drove into shallow ditch; hit culvert, impaled head in cab</td>
<td>R</td>
<td></td>
<td>W</td>
<td>6-10</td>
<td>P</td>
<td>59</td>
<td>Y</td>
<td>Alcohol, seat belt not used</td>
<td></td>
</tr>
<tr>
<td>EC 8</td>
<td>Moving machinery along side hill, tractor OT and pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>35</td>
<td>N</td>
<td></td>
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</tr>
<tr>
<td>NE 5</td>
<td>Driving downhill w/large round bale chained in bucket, OT and pinned</td>
<td>F</td>
<td>S</td>
<td>N</td>
<td>&gt;10</td>
<td>P</td>
<td>67</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>Backing up incline, OT</td>
<td></td>
<td></td>
<td></td>
<td>&gt;10</td>
<td>P</td>
<td>22</td>
<td>N</td>
<td>Visiting, helping grandfather</td>
<td></td>
</tr>
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</tr>
</tbody>
</table>

None of the operators wore a seat belt

Overtur = OT; S = side; R = rear;
P = operator, T = other

N = narrow front; W = wide front; SKL = skid loader; FWA = front wheel assist; and 4WD = 4 wheel drive

All responses indicated with a -, = unknown

All males, unless female noted in comments column