RESEARCH CIRCULAR 287 JUNE 1985

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ACKNOWLEDGMENTS

Salaries and research support were provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center and The Ohio State University.

The authors wish to recognize several contributors to the research project. Special recognition is given to the Samuel Frantz family, who made a generous financial contribution to the project in memory of their grandson who was killed in a farm accident. The Nationwide Insurance Corp., the Ohio Cooperative Extension Service, and the National Institute for Farm Safety also made financial contributions to the project. Without the aid of these contributors, the project would not have been possible.

The authors wish to thank Lyndal K. Napier for secretarial support during the writing phase of this project. The authors also wish to thank Joseph Donnermeyer, Thomas Stout, and Alvin Bertrand, who reviewed the manuscript and made useful suggestions for improving the report.

AGDEX 884

6-85-2.5M

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INTRODUCTION

Accidents have been the subject of significant concern among farm populations for many years, but tangible results from the recognition of accidents as a farm problem were not realized until the mid-1940's when the National Farm Safety Institute (NFSI) was organized. Soon after the formation of the NFSI, several farm safety programs came into being and organized efforts were undertaken to reduce the incidence of farm accidents. In 1959, for example, the first conference on farm safety research was initiated by the National Safety Council, the U. S. Dept. of Agriculture, and the Farm Foundation. Practitioners and researchers systematically began to examine farm safety research needs and several of the issues identified at that time are appropriate today (15, 33). Conference participants agreed that research was needed to isolate the factors contributing to the incidence of various types of farm accidents and observed that information was needed concerning how attitudes affect the incidence of farm accidents. They also suggested that research was needed to isolate the conditions which contribute to safe working habits on the farm and how farm safety could be integrated into farm family goals.

Research focused on farm accidents in Ohio was initiated in 1957 by the Ohio Cooperative Extension Service and the Ohio Agricultural Research and Development Center. The studies have been repeated every 5 years to the present. The study being reported here is the sixth in the safety study series. The primary objectives of the five previous studies were: 1) to provide profiles of farm accidents by noting the types and severity of the accidents; 2) to examine how and where the accidents occurred; and 3) to identify the accident prevention and safety practices being used by rural people. While several variables were examined using bivariate analyses, relatively little attention was given to the assessment of the factors associated with the frequency of farm accidents using multivariate statistics.

The purpose of this bulletin is to present updated information regarding farm accidents using the research tradition established in the preceding Ohio studies. This goal is accomplished by presenting descriptive data concerning the nature and extent of farm-related accidents for the study participants during the 1980-1982 time period. Past efforts will be extended, however, through use of multivariate analyses of the data in an attempt to identify socio-demographic, attitude, and farm structure variables which are predictive of the frequency of farm-related accidents. The study findings are discussed in the context of applied prevention programs.

FARM SAFETY LITERATURE

A review of the existing literature devoted to the investigation of farm safety reveals that relatively little has been done to isolate predictive factors associated with the frequency and type of farm accidents using multivariate analysis. However, there have been several studies which have evaluated the frequency and type of farm accidents using bivariate statistical techniques and descriptive statistics. Several of these studies are discussed below.

The relationship of farm size and frequency of farm accidents has been shown to be significant. Phillips, *et al.* (29) discovered that farmers of larger farms tended to have significantly more accidents than operators of smaller farms. These authors suggest that greater exposure to farm machinery and higher risk situations on the larger farms were explanations of the significant differences noted. Similar findings were reported by Bertrand (5) and Patterson, *et al.* (28) in Louisiana and by Erisman and Huffman (10) in Illinois. Research among Michigan farmers (15), however, revealed that no significant relationship was identifiable between these two variables.

Another factor which has been noted to be consistently related to farm accidents is gender. Males have repeatedly been shown to be more prone to farm accidents than females (9, 13, 15, 16, 29). The findings are explained in terms of greater exposure to farm machinery by males. While it is true that females tend to actively participate in farm work, it is argued by these authors that males tend to have greater exposure to complex farm machinery.

The relationship of education and the incidence of farm accidents is much less consistent than the previously discussed variables. Gadalla (12) noted that farmers who were high school graduates tended to have higher accident rates, while Bertrand (5) observed that higher educated farmers had significantly fewer farm-related accidents. Later studies produced insignificant relationships between education and accident involvement (28, 29).

Several other variables have been shown to have little utility in explaining the incidence of farm accidents. Hofmeister and Pfister (15) discovered that the amount of time spent doing farm work was not significantly related to accident involvement. They also observed no significant differences between accident rates and type

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of farming operation, such as beef, dairy, fruit, hog, poultry, and other types of farming operations. Murphy (23) discovered no significant differences among Pennsylvania farmers in terms of attitudes toward farm safety and the incidence of farm accidents. This latter finding suggests that prevention programs designed to create more positive attitudes toward farm safety among active farmers may have relatively little effect. This finding also suggests that attitudes toward farm safety may not be as important as commonly thought in reducing farm accidents.

Research by Stout and Darbee (35) added several interesting factors to the explanatory matrix. These authors revealed that conscious risk acceptance, mental distractions, and stress associated with deadlines contributed to severe injury. They also observed that more experienced farmers tended to have more serious accidents. The latter finding is of particular interest since it is commonly asserted that experience in role playing often results in better performance.

While the literature noted above has demonstrated that several socio-demographic and farm structure variables have been shown to be significantly related to the incidence of farm accidents, relatively little attention has been focused on the *degree* of association of these factors to the incidence of farm related accidents. Therefore, little can be said about *how* predictive these factors are of the number of farm accidents. The purpose of this bulletin is to undertake such a task.

The remaining sections of this bulletin are designed to address the issues noted above. The next section discusses the theoretical modeling used in the study, followed by the research methods employed. The subsequent section presents the descriptive data provided via questionnaires by the study respondents. The descriptive findings are presented to be consistent with the research tradition established in former safety studies. The descriptive findings are discussed in the context of the nature and incidence of farm accidents in Ohio. The next section presents the multivariate tests of the theoretical model. The concluding portion of this report consists of a discussion of the study findings and recommendations for accident prevention programs and future research endeavors.

THEORETICAL MODELING

The literature focused on farm accidents noted above clearly indicates that both social characteristics of farmers and characteristics of farm operations influence the incidence of farm-related accidents. Since no single theory exists to integrate the two types of factors, an eclectic theoretical perspective was constructed from selected components of social learning theory which is a derivative of behaviorism (3, 21, 22, 32, 34) and theoretical modeling associated with the increasing scale of agriculture (7, 11, 14, 31).

Social learning theory is a special type of behaviorism which argues that the enactment of a particular behavior is a function of a sequence of past experiences. The perspective asserts that experience provides the actor with information which enables the person to evaluate the relative merits of behavior previously enacted. These experiences provide the information base to attach meaning to behaviors and to make assessments of benefits and costs associated with specific actions. Thus, the model suggests that the propensity to enact specific behavior is governed by assessments of past experiences with the behavior in question or with similar behaviors.

The application of this conceptual modeling to farm accidents suggests that "accident prevention" behavior is learned from antecedent events and learning experiences. This suggests that factors such as previous farming experiences, exposure to information related to agricultural practices, and exposure to technologies for reducing farm accidents should result in a decline in the number of farm accidents since these activities should provide knowledge of how to avoid accidents. The learning theory (3, 4) elements of the previous modeling suggest that individuals learn that certain actions produce undesirable outcomes and should be avoided. Behaviors are enacted to avoid undesirable outcomes and to maximize desirable consequences. Subsequently, farmers should enact behaviors which they have learned will result in the reduction in the number of farm accidents. Given these theoretical arguments, it is hypothesized that indicators of farming experience, measures of exposure to information related to farming practices, and exposure to farm safety techniques and technologies will be significantly related to the incidence of farm-related accidents. It is hypothesized that as farming experience and exposure to knowledge increase, there will be a concomitant decrease in the number of farm-related accidents.

The second component of the theoretical perspective developed for this study is derived from modeling focused on the impacts of increasing scale of agriculture. Social scientists have documented the trend toward high scale farming operations in U. S. agriculture which have produced the following structural changes: 1) an increase in the average farm size with a concomitant decrease in the number of farms; 2) an increase in average farm production; 3) an increase in the mechanization of the farm enterprise; and 4) an increase in the use of hired labor and decreased use of family labor (2, 7, 11, 14, 31).

As farms become more complex in terms of the use of technologies, the probabilities also increase that farm-related accidents will occur. Greater reliance on complex machinery tends to expose operators to greater levels of risk. In like manner, larger numbers of hired workers who are engaged in continuous operation of complex farm machinery to meet deadlines for planting and harvest tend to increase exposure to potential accidents. Obligations to meet contracts and production schedules put considerable pressure on farmers to extend themselves, their hired labor, and their equipment, which increases the probabilities that accidents will occur.

Given the situations noted above, it is argued that measures of farm scale will be significantly related to the incidence of farm-related accidents. It is expected that as the scale of the farm operation increases, there will be more farm-related accidents.

In essence, the theoretical perspective developed for this study argues that a more comprehensive model for explaining frequency of farm-related accidents is achieved by combining elements of social learning theory and measures of farm structure. The model basically argues that farmers are influenced by learning experiences which tend to reduce the number of accidents. In like manner, farmers are affected by market forces which often result in the emergence of complex farming operations. The outcome of such a situation is often increased exposure to accidents.

STUDY METHODOLOGY

Sample Selection

Data were collected in the late spring and summer of 1982 from 918 Ohio farmers. The study respondents were systematically sampled from nine counties randomly selected from the Extension districts. Only farmers with *gross* farm income greater than or equal to $1,000 during the previous crop year were defined as being eligible for inclusion in the study. It is recognized that use of this criterion effectively excluded very small farming operations from the sampling frame. Interpretation of the findings must be made in the context of this sampling limitation.

Interviewers were recruited by the Extension agent in each of the study counties. Volunteers were solicited from residents of the study counties to conduct interviews because budget constraints precluded hiring professional field staff. The completeness of the questionnaires and the thoroughness with which the interviewers complied with the interviewing instructions strongly suggest that the volunteers performed their role very well. The cost per completed interview using the volunteer interviewers was approximately 33 cents excluding the principal investigator's salary and the county agents' time.

A structured questionnaire was developed by sociologists in the Dept. of Agricultural Economics and Rural Sociology, Ohio Agricultural Research and De-

TABLE 1.—Summary Characteristics of Sample (N = 918) Compared with the 1982 Census of Agriculture for Ohio.

	Sample (1982)	Census of Agriculture* (1982)
Age of Farmer (%)	<35 = 17.9	<35 = 17.5
	35-44 = 23.0	35-44 = 20.5
	45-54 = 24.9	45-54 = 22.0
	55-64 = 22.7	55-64 = 23.2
	>65 = 10.2	>65 = 16.7
	No data = 1.3	Not applicable
	$\bar{x}$ = 47.8 years	$\bar{x}$ = 49.8 years
Years of Farming	$\bar{x}$ = 26.8 years	Not available
Farm Size by Acres Owned (%)	1-49 = 27.7	1-49 = 28.7
	50-179 = 35.5	50-179 = 41.4
	180-499 = 27.6	180-499 = 22.4
	500-999 = 5.9	500-999 = 5.9
	1,000-1,999 = 1.0	1,000-1,999 = 1.5
	>2,000 = 0.1	>2,000 = 0.1
	No data = 2.2	Not applicable
	$\bar{x}$ = 175.9 acres	$\bar{x}$ = 177.0 acres
Tractor Ownership	$\bar{x}$ = 3.3	$\bar{x}$ = 2.2
Combine Ownership	$\bar{x}$ = 0.9 combines	$\bar{x}$ = 0.4
Farmers Using Hired Labor (%)	38.2	31.6
Source of Agricultural Income for Last 3 Years (%)	Crops 50.8	55.0†
	Livestock/other 39.7	45.0
	No data 9.5	Not applicable
Farmers with 100 Days or More Off-farm Employment (%)	33.1	49.3

*Source: (36).
†Data for 1982 crop year only.

velopment Center and The Ohio State University. The questionnaire was presented to "key" safety specialists in the OSU College of Agriculture for examination and criticism. The questionnaire was reformulated and presented to the volunteer interviewers during a 2-hour group training session. The field interviewers were not only trained in the use of the questionnaire but also in the sample selection and interviewing techniques to be used in the study.

A modified systematic sampling technique appropriate for selecting study participants from dispersed farm populations was used to select the sample (24, 25, 26, 27). The interviewers were assigned a sampling area and were instructed to select 10 farm families along a specified road by choosing every 10th occupied farmstead. If the selected farmer did not meet the criterion of $1,000 gross farm sales in the previous year or did not wish to participate, the interviewer was instructed to select the adjacent occupied farm until an interview was granted. The interviewers reported that more than 95% of all farmers who met the criterion for inclusion in the study and were asked to participate in the study actually completed a questionnaire. Selected sample characteristics are presented in Table 1 with comparable data from the 1982 Census of Agriculture to assess how closely the sample data compare with known characteristics of farmers in Ohio.

Table 1 reveals that the sample characteristics are very similar to the 1982 farm census data with the exception of off-farm employment and percent of farmers using hired labor. These differences could be a function of the economic problems which farmers have encountered in recent years. Farmers must cut costs of production to remain competitive and could do so via reduction of labor costs. Without hired labor, many farmers would not be able to allocate time to nonfarm employment. Given the very competitive market situation, farmers may be required to work longer hours to maintain production levels necessary to survive which precludes employment off-the-farm. Given the similarity of the sample data to those of the farm census presented in Table 1, the wide geographic distribution of the sample, and the large sample size, it is argued that the data are adequate for preliminary assessments of factors associated with farm accidents in Ohio.

Measurement of Study Variables

The literature review and theoretical modeling provided the underpinnings for the selection of the study variables. The variables included in the study to represent the farm structure component of the theoretical model are as follows: number of farm laborers, acres under cultivation, number of tractors owned, tractor size, use of combine, use of drying equipment, use of liquid application equipment, use of grain storage, transportation of farm products, percent grain farmer, and percent livestock farmer. The variables purported to represent the social learning component of the theoretical perspective are as follows: years of farming, agricultural education, safety equipment index, and safety awareness. The variables chosen for investigation can be grouped into three broad categories which are farm accident and safety factors, farm structure factors, and socio-demographic factors. The variables were operationalized in the following manner.

Farm Accident and Safety Factors

Number of Farm-related Accidents: The respondents were asked to indicate the number of accidents which had occurred on their respective farms during the previous 3 years which involved the principal farm operator, his/her family members, and/or hired employees. The respondents were asked to report the number of accidents which resulted in the loss of one-half day or more from normal activities, required professional medical care, or resulted in death. The respondents were cautioned to only report accidents which occurred as a result of operating or maintaining their farming enterprises. It is recognized that the length of time (3 years) may have introduced some recall error since all accidents of a less serious nature may not have been reported.

Causes of Accidents: The respondents were asked to note what contributed to the farm-related accidents. A list of 13 possible causes were presented on the questionnaire and the respondents were instructed to specify how many accidents were caused by each. The causes listed were: chainsaws, falls, fire, poison, explosion, farm animals, farm machinery, electricity, chemicals, falling objects, motor vehicles, farm tractors, and other.

Farming Activity at Time of the Accident: The respondents were asked to note what the injured person was doing at the time the farm accident occurred. They were asked to note the number of accidents for each activity listed. The 22 activities presented for evaluation were: drying grain, loading grain, unloading grain, plowing, repairing machinery in shop, repairing machinery in the field, clearing grass/weeds, herding animals, feeding animals, clearing land for farming, moving equipment from one field to another, cutting firewood, transporting crops to market, picking corn, storing hay, mowing roads, operating brush hog, laying drain tile, combining grain, baling hay, disking, and other.

Safety Equipment in Use: Safety equipment in use was evaluated by asking the respondents to indicate what types of safety equipment were being *used* on the farm at the time of the study. If the respondents indicated that a specific safety device was used, the variable was given a value of 1. A negative response received a value of 0. The nine safety devices evaluated were: fire extinguisher, hard hat, steel-toed shoes, safety glasses, fire sensors in farm buildings, protective clothing, two-way radios, squeeze water bottle for anhydrous ammonia spills, and smoke detectors in the farm house. The weighting values were summed to form a composite index for multivariate analyses.

Safety Awareness: Safety awareness was measured using a five-item, Likert-type attitude scale designed to assess how well the respondents felt they were informed about farm safety. The items evaluated how well informed the respondents perceived themselves to be about the following issues: *causes* of farm accidents; *means* of preventing farm accidents; *characteristics* of farm families most likely to have farm accidents; *conditions* which increase the probability of farm accidents; and *conditions* which are dangerous on farms. The possible responses to each of the items ranged from "not well informed" to "very well informed." The weighting values ranged from 0 to 7, with 0 representing "not well informed" and a value of 7 representing "well informed." The responses to the items were initially examined using internal consistency item analysis to ascertain the reliability of the composite scale. The items were shown to be highly intercorrelated and the item analysis produced an alpha coefficient (8) of 0.88 which indicates a high degree of internal consistency.[2] The weighting values were summed to form a composite index of safety awareness and used in the multivariate analyses.

Number of Work Days Lost: The respondents were requested to note how many work days the injured person lost due to farm accidents. The actual number of days reported was used in the descriptive analyses.

Farm Structure Factors

Acres Usually Under Cultivation: The study respondents were requested to indicate the total number of acres *usually* under cultivation each crop year by the principal farm operator.

Number of Tractors Owned: The number of tractors owned by the principal operator at the time of the study was requested.

Tractor Size: Information regarding the horsepower of the largest tractor being used by the principal farm operator at the time of the study was requested.

Use of Combine: The respondents were asked if a combine harvester was presently being used on their farms. A "yes" response received a value of 1, while a "no" response received a value of 0.

Mechanical Drying Equipment: The respondents were asked if mechanical drying equipment was presently being used on their farms. A "yes" response received a value of 1, while a "no" response received a value of 0.

Liquid Application Equipment: The respondents were asked if liquid application equipment for five types of chemicals (herbicides, ammonia, liquid fertilizer, pesticides, other) was presently being used on their farms. A "yes" response received a value of 1, while a "no" response received a value of 0. The values were summed to form a composite index of application equipment in use.

Grain Storage: The respondents were asked to note if grain storage was available on their farm at the time of the study. A "yes" response received a value of 1, while a "no" response received a value of 0.

Transportation of Farm Products: The respondents were asked if the principal farm operator transported his/her own farm products to market. A "yes" response received a value of 1, while a "no" response received a value of 0.

Percent Grain Farmer: The type of farm enterprise was determined by asking the respondents to indicate the percentage of gross farm income for the last *3 years* derived from each product listed. The percentages for soybeans, corn, and wheat were summed to form a composite index termed percent grain farmer.

Percent Livestock Farmer: The percentages of gross farm income for the last *3 years* derived from poultry, beef, dairy, swine, and sheep were summed to form an index termed percent livestock farmer.

Socio-Demographic Characteristics

Number of Hired Laborers Working on the Farm: The number of hired employees was measured by asking the respondents to indicate the number of nonfamily individuals who work on the farm.

Years of Farming: The respondents were asked to indicate the number of years the principal farm operator had been engaged in farming.

Agricultural Education: Agricultural education was measured in terms of the number of agricultural education activities in which the primary farm operator had participated during his/her lifetime. Seven different educational experiences evaluated were: 4-H; vocational agriculture courses in high school, vocational agriculture courses in adult education programs, college short course in agriculture, attended an agricultural college, graduated from an agricultural college, and on-the-job training by working for another farmer. The respondents were instructed to check all relevant educational experiences. A "yes" response to each of these educational activities received a value of 1, while a "no" response received a value of 0. The weighting values for each of these educational experiences were summed to form a composite index for use in the multivariate analyses.

Farming Status: The respondents were asked if the principal farm operator had worked more than 100 days in off-farm employment in the previous year. A "yes" response received a value of 1, while a "no" response received a value of 0. Individuals who had worked more than 100 days in off-farm employment were defined as part-time farmers.

DESCRIPTIVE FINDINGS

Frequency of Farm-related Accidents

The descriptive data for the study sample revealed that 277 or 30.2% of the farm families interviewed had experienced at least one farm-related accident during the preceding 3 years. Of the respondents reporting accidents, 66.4% indicated their families had been involved in only one accident during the past 3 years. The frequency of accidents ranged from 0 accidents for 641 (69.8%) farmers to 10 accidents for 5 of the farmers. There were 448 reported accidents for the 1980-1982 time period, which converts to 0.49 accidents per farmer using the total sample for computation purposes. The accident data were disaggregated by farming status

[2]The scale items were also factor analyzed using principal component analysis. A one-factor solution was obtained, with all items exhibiting factor loadings equal to or exceeding 0.75. This is further evidence of the reliability of the scale.

TABLE 2.—Total Farm-related Accidents by Full-time and Part-time Farming Status, 1980-1982: Ohio Farm Survey Data.

No. of Accidents Experienced	Full-time Farmer (N = 614)	Part-time Farmer (N = 304)	Accidents for Total Sample (N = 918)
0	424	217	641
1	121	63	184
2	44	17	61
3	17	4	21
4	3	0	3
5	1	0	1
6	1	1	2
7	0	0	0
8	0	0	0
9	0	0	0
10	3	2	5
Total No. of Accidents	313	135	448

TABLE 3.—Analysis of Variance for Full-time and Part-time Farmers for Total Farm Accidents: Ohio Farm Safety Survey Data (N = 918).

Study Group	Mean No. of Accidents	Source of Variation	Sum of Squares	F-Ratio	Significance Level
Full-time Farmers (N = 614)	0.5	Main effects	0.88	0.78	0.379
		Explained	0.88		
Part-time Farmers (N = 304)	0.4	Residual	1.14		
		Total	1.14		

TABLE 4.—Percent Serious Injury of the Total Number of Accidents Experienced by Full-time and Part-time Farmers: Ohio Farm Safety Survey Data.

Outcome of Accident	No. of Accidents by Full-time Farmers (N = 313)		No. of Accidents by Part-time Farmers (N = 135)		Total No. of Farm Accidents for Sample (N = 448)	
	No. of Serious Accidents	Percent of Total Accidents for Group	No. of Serious Accidents	Percent of Total Accidents for Group	No. of Serious Accidents	Percent of Total Accidents for Group
Sutures	90	28.8	40	29.6	130	29.0
Hospitalization	55	17.6	22	16.3	77	17.2
Loss of Sight	9	2.9	1	0.7	10	2.2
Loss of Hearing	2	0.6	0	0.0	2	0.4
Loss of Limbs	4	1.3	7	5.2	11	2.5
Death	1	0.3	0	0.0	1	0.2
Total No. of Serious Accidents	161	51.5	70	51.8	231	51.5

(full-time farmer and part-time farmer) and the findings are presented in Table 2.

Examination of Table 2 demonstrates that full-time farmers outnumber part-time farmers slightly more than two to one and that full-time farmers experienced proportionately more accidents than part-time farmers. One-hundred and ninety (30.9%) of the full-time farmers experienced at least one accident while 87 (28.6%) of the part-time farmers experienced at least one accident. Such data suggest that significant differences could exist between full-time and part-time farmers in terms of farm-related accidents. To assess this possibility, an analysis of variance was conducted on the data. Farming status was designated as the criterion variable and the number of accidents was compared for the two groups. The analysis of variance statistics are presented in Table 3.

The findings presented in Table 3 demonstrate that farming status is *not significantly* related to the number of farm-related accidents. This finding means that greater exposure to farming activity (working more days on the farm) by full-time farmers is *not* a significant contributor to farming accidents.

Frequency of Serious Injury

The number of serious accidents was examined to ascertain the nature and incidence of more serious farm accidents. A serious accident was nominally defined as being any accident that resulted in sutures, hospitalization, loss of sight, loss of hearing, loss of limbs, or death. The frequency counts for this variable are provided in Table 4 disaggregated by farming status.

The data presented in Table 4 show that one-half of *all* the farm accidents reported resulted in serious injury using our definition of the concept. Both groups of farmers were very similar in terms of percentages of injuries in each category. The only accident outcome which differed to any extent was loss of limbs. Part-time farmers had a higher percentage of loss of limbs than full-time farmers. It should be noted, however, that the number of accidents resulting in loss of limbs was quite small for both groups of farmers. The data presented in Table 4 strongly suggest that when farmers experience a farm-related accident, it will probably result in relatively serious injury using our definition of the term.

Number of Farm Work Days Lost Due to Accidents

Data were collected for the number of work days lost on the farm as a result of accidents. These data are presented in Table 5 and show that 19.6% of the farmers experiencing accidents also lost work days. About 21.8% of the full-time farmers and 15.1% of the part-time farmers who had experienced farm accidents actually lost work days. The number of days lost was relatively large (6.5 days per accident). Full-time farmers lost an average of 6.3 days per farm accident while part-time farmers lost an average of 6.8 work days. The average number of days lost per farmer who had *experienced an accident* was 16.1 days. Comparisons of full-time farmers with part-time farmers who had experienced accidents show that full-time farmers lost 14.8 days while part-time farmers lost 20.1 days. Such long recuperation periods suggest that the injuries sustained in farm accidents are rather substantial. Such a conclusion is consistent with the findings presented in Table 4 which show that more than 50% of the farm accidents reported were serious using our definition of the term.

Comparison of the findings reported in Table 5 collected for an earlier study of Ohio farmers (30) demonstrates that the 1982 sample lost more work days per accident. The increase in days lost per accident is something to be concerned about because expanding recuperation periods suggest increasing severity of the accidents.

Given the observed differences between full-time and part-time farmers for work days lost, an analysis of variance was conducted on the data to determine if there

TABLE 5.—Number of Work Days Lost Due to Farm-related Accidents for Full-time and Part-time Farmers: Ohio Farm Safety Survey Data.

	Full-time Farmers (N = 614)	Part-time Farmers (N = 304)	Combined Part-time and Full-Time (N = 918)
Total No. Losing Work Days	134 farmers	46 farmers	180 farmers
Total Work Days Lost Due to Accidents	1,980 days	924 days	2,904 days
Total No. of Accidents	313	135	448
Mean No. of Days Lost per Accident	6.3 days	6.8 days	6.5 days
Farmers Who Lost Work Days	21.8%	15.1%	19.6%
Average No. of Days Lost per Farmer with Accidents	14.8 days	20.1 days	16.1 days

were significant differences between the two groups. The findings are presented in Table 6 and show that no significant differences were identifiable between the two study groups. Farming status does *not* affect the number of lost days from farm work due to accidents.

Causes of Farm Accidents

The causes of farm accidents were explored by asking the respondents to note how many of the reported accidents could be attributed to several types of causes examined via the questionnaire. There were 13 possible responses for the respondent to indicate the number of accidents associated with each. These data are presented in Table 7 and show that the most frequent cause of farm accidents is farm machinery. About 23.4% of the respondents indicated the reported accidents were caused by farm machinery. Falls were the next most important cause (19.0%) while farm animals were the third (15.4%). These three causes accounted for 57.8% of all farm accidents. If motor vehicles[3] and tractors are considered farm machinery, then the percentage is increased to 68.7%. These findings suggest that programs designed to reduce the incidence of farm accidents should be focused on these causes since they account for such a large percentage of the accidents which occur.

Comparison of farm accident causes by full-time and part-time farming status reveals several differences. The most frequent causes for both groups of farmers were falls, farm animals, and farm machinery. The rank order of frequency varies but the categories are high for both. The most frequent causes of accidents for full-time farmers were machinery, falls, and farm animals. The rank ordering for the part-time farmers was falls, farm animals, and farm machinery. These differences

[3]The respondents were cautioned to report only accidents related to the operation and maintenance of the farm, which excluded personal use accidents. The reported accidents for vehicles were related to the operation of the farm.

TABLE 6.—Analysis of Variance Findings for Full-time and Part-time Farmers for Work Days Lost Due to Farm Accidents: Ohio Farm Safety Survey Data.

Study Groups	Mean	Source of Variation	Mean Square	F-Ratio	Significance Level
Full-time Farmers (N = 134)	14.8	Main effects	694.2	0.91	0.343
		Explained	694.2		
		Residual	766.9		
		Total	766.5		
Part-time Farmers (N = 46)	20.1				

TABLE 7.—Causes of Farm Accidents by Full-time and Part-time Farming Status: Ohio Farm Safety Survey Data.

Cause of Accident	No. of Accidents for Full-time Farmers (N = 313): No. of Accidents	Percent of Accidents for Group*	No. of Accidents for Part-time Farmers (N = 135): No. of Accidents	Percent of Accidents for Group*	No. of Accidents for Combined Group (N = 448): No. of Accidents	Percent of Accidents for Group*
Chainsaws	11	3.5	14	10.4	25	5.6
Falls	55	17.6	30	22.2	85	19.0
Fire	4	1.3	3	2.2	7	1.6
Poison	1	0.3	0	0.0	1	0.2
Explosion	3	1.0	0	0.0	3	0.7
Farm Animals	41	13.1	28	20.7	69	15.4
Farm Machinery	80	25.6	25	18.5	105	23.4
Electricity	1	0.3	0	0.0	1	0.2
Chemicals	1	0.3	2	1.5	3	0.7
Falling Objects	14	4.5	3	2.2	17	3.8
Motor Vehicles	11	3.5	9	6.7	20	4.5
Farm Tractors	27	8.6	2	1.5	29	6.5
Other	64	20.4	19	14.1	83	18.5

*Percentages may not sum to 100.0 due to rounding error.

are probably due to the degree of mechanization on the respective farms since part-time farmers tend to have less extensive farm machinery (Table 9). Chainsaws were involved in approximately three times as many accidents for part-time farmers as full-time farmers. Motor vehicles caused a higher percentage of accidents for part-time farmers. Farm tractors caused almost six times as many accidents for full-time farmers as they did for part-time farmers. Very few accidents were caused by fire, poison, explosion, electricity, and chemicals.

The final category in the list of causes was *other*. This category was included to provide a response category for accidents which could not be subsumed under one of the specified categories. The respondents were instructed to note the specific cause of the accident if they selected the "other" category. Several people chose this category and entered the causes. The most frequently mentioned causes were use of farm tools such as drills, welders, log splitters, and hay hooks.

Activities at Time of Accident

Data were collected which could be used to determine what the individuals were doing when the reported accidents occurred. These data are presented in Table 8 and reveal that repairing machinery and herding/feeding animals were by far the most common activities at the time of the accident. These data support the findings reported in Table 7 focused on causes.

Repairing machinery accounted for 21.4% of the activities when accidents occurred, while feeding and herding animals accounted for an additional 22.5%. Programs designed to prevent farm accidents should be focused on these farming activities since they compose a large minority of all activities at the time the farm accidents occurred. Farmers should be cautioned to employ additional prevention practices when they are engaged in these farming activities.

The relatively small number of accidents associated with processing grain is quite surprising given the

TABLE 8.—Activities Being Performed at Time of Accident for Full-time and Part-time Farmers: Ohio Farm Safety Survey Data.

Activity Being Performed	No. of Accidents for Full-time Farmers (N = 250)*		No. of Accidents for Part-time Farmers (N = 105)*		No. of Accidents for Combined Group (N = 355)*	
	No. of Accidents	Percent of Accidents for Group†	No. of Accidents	Percent of Accidents for Group†	No. of Accidents	Percent of Accidents for Group†
Drying Grain	0	0.0	0	0.0	0	0.0
Loading and Unloading Grain	11	4.4	1	1.0	12	3.4
Combining Grain	6	2.4	5	4.8	11	3.1
Picking Corn	3	1.2	2	0.2	5	1.4
Plowing and Disking	8	3.2	2	0.2	10	2.8
Repairing Machinery in Shop	39	15.6	12	11.4	51	14.4
Repairing Machinery in Field	17	6.8	8	7.6	25	7.0
Herding Animals	27	10.8	17	16.2	44	12.4
Feeding Animals	26	10.4	10	9.5	36	10.1
Clearing Land and Mowing	14	5.6	4	3.8	18	5.1
Moving Equipment from Field to Field	11	4.4	2	1.9	13	3.7
Baling and Storing Hay	18	7.2	8	7.6	26	7.3
Cutting Firewood	12	4.8	9	8.6	21	5.9
Transporting Crops to Market	2	0.8	1	1.0	3	0.8
Laying Drain Tile	4	1.6	0	0.0	4	1.1
Other Activity	52	20.8	24	22.9	76	21.4

*The magnitude of the N's varies from previous values because respondents could not recall the activity being performed for every accident which occurred.

†Percentages may not sum to 100.0 due to rounding error.

importance of grain production to Ohio farmers and the complex technologies used in the processing activities. Drying grain, loading/unloading grain, combining, and picking grain accounted for only 28 accidents (7.9% of total reported accidents). This is a very low number of accidents given the proportion of farmers engaged in grain production and the short time frame used in processing the "mountains of grain" produced in the state. One would expect the rapidity with which grain is processed for marketing purposes to contribute to many accidents but this is not the case.

The data presented in Table 8 also show that full-time and part-time farmers were engaged in similar activities when the accidents occurred. Repairing farm equipment and caring for farm animals were the activities most often reported when the accidents took place. The ordering of the activities varied somewhat but the activities were basically the same for both groups.

One of the categories included in the list of activities was called "other" to solicit information about activities which could not be subsumed under the categories presented. The respondents used this category rather frequently and indicated that activities such as hauling gravel, storing equipment, bedding stalls, opening silos, and repairing drain tile were the activities most often being enacted when accidents occurred.

Use of Roll Over Protection Structures (ROPS)

Many safety devices are available to reduce the incidence of farm accidents or to reduce the seriousness of injury if accidents do occur. One of the most frequently discussed safety devices is roll over protection structures (ROPS) for farm tractors. The Occupational Safety and Health Act (OSHA) requires the use of such safety devices on farms with 10 or more hired employees if the tractor is being operated by a hired employee.[4] Previous research conducted in 1977 demonstrated that only 12.5% of Ohio farmers included in the sample were using ROPS at the time of the study (37). Data concerning the use of ROPS were collected in this study to ascertain if the use of ROPS had changed over time. To satisfy this research objective required information regarding the total number of tractors owned and the number with ROPS. The findings for tractors owned and those equipped with ROPS are presented in Table 9.

The data presented in Table 9 show that 26.5% of the tractors owned by full-time farmers were equipped with ROPS while the corresponding figure for part-time farmers was 15.0%. While both groups of farmers exhibited higher rates of adoption than the corresponding data for 1977, the rate of adoption has been quite low. Only 23.4% of all tractors owned by the study respondents were equipped with ROPS.

The descriptive data presented in Table 9 suggest that farming status could be a significant factor in predicting tractor ownership and use of ROPS. To examine this possibility, an analysis of variance was conducted on the data using farming status as the criterion variable to partition the study participants. The results of these analyses are presented in Table 10.

The findings presented in Table 10 show that significant differences were observed between full-time and part-time farmers for both the number of tractors owned and for tractors equipped with ROPS. The explained variance for both analyses, however, revealed that farming status was of little consequence in terms of explaining the differences between the two groups. Only 7% of the variance could be explained by farming status for both the number of tractors owned and for tractors equipped with ROPS. These analyses indicate that farming status has little substantive meaning for explaining the differences between full-time and part-time farmers in terms of tractors owned and ROPS used.

A possible explanation for the significant differences observed between full-time and part-time farmers in the use of ROPS is that full-time farmers tend to operate

[4]Safety specialists with the Ohio Cooperative Extension Service have been stressing the adoption of ROPS in their safety educational programs for several years. The central thesis of these programs is that ROPS should be used on all tractors.

TABLE 9.—Number of Tractors Owned and Proportion of Tractors Using Roll Over Protection Structures (ROPS) for Full-time and Part-time Farmers: Ohio Farm Safety Survey Data.

	Full-time Farmers (N = 574)	Part-time Farmers (N = 284)	Combined Group (N = 858)
Total No. of Tractors Owned	2,223	819	3,042
Average No. of Tractors Owned	$\bar{x} = 3.7$ SD = 1.0	$\bar{x} = 2.7$ SD = 0.4	$\bar{x} = 3.37$ SD = 0.8
Total No. of Tractors with ROPS	589	123	712
Average No of Tractors with ROPS	$\bar{x} = 1.0$ SD = 1.1	$\bar{x} = 0.4$ SD = 0.7	$\bar{x} = 0.8$ SD = 1.1
Tractors with ROPS (%)	26.5%	15.0%	23.4%

larger farms and have newer equipment than part-time farmers. Newer tractors have higher probability of being equipped with ROPS than tractors manufactured prior to the introduction of the tractor safety legislation. It is also highly probable that full-time farmers will have more hired employees than part-time farmers and will be required by OSHA to have ROPS on their tractors.

Safety Equipment Used

Safety equipment presently being used on the farm was assessed to provide some insight into prevention

TABLE 10.—Analysis of Variance Findings for Tractor Ownership and Use of Roll Over Protection Structures (ROPS) by Farming Status: Ohio Farm Safety Survey Data.

Study Groups	Mean	Source of Variation	Mean Square	F-Ratio	Significance Level
		Farm Tractors Owned (N = 858)			
Full-time Farmers (N = 574)	3.7	Main effects	174.2	60.2	0.001
		Explained	174.2		
		Residual	2.9		
Part-time Farmers (N = 284)	2.7	Total	3.1		
		$\bar{R}^2 = 0.07$			
		Use of ROPS (N = 858)			
Full-time Farmers (N = 574)	1.0	Main effects	65.3	63.0	0.001
		Explained	65.3		
		Residual	1.0		
Part-time Farmers (N = 284)	0.4	Total effects	1.1		
		$\bar{R}^2 = 0.07$			

TABLE 11.—Types of Farm Safety Equipment Being Used on Ohio Farms: Ohio Farm Safety Survey Data.

Type of Safety Device Used	Percent Using Safety Equipment: Full-time Farmers 1982	Part-time Farmers 1982	Total Sample 1977*	Total Sample 1982
Fire Extinguisher	71	56	n.a.	66
Hard Hat	10	8	8	9
Steel-toed Shoes	17	36	21	24
Safety Glasses	65	61	60	64
Fire Sensors in Farm Buildings	7	5	n.a.	6
Protective Clothing	37	34	n.a.	36
Two-way Radios	19	13	16	17
Squeeze Bottle of Water with Anhydrous Ammonia	31	14	9	25
Smoke Detectors in Home	67	68	14	67

n.a. — Data not available.
*Source — Young, Clair W. and G. Howard Phillips. 1979. Accidents in Rural Ohio — 1977. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 252, and Ohio Coop. Ext. Serv., EB664.

devices being employed by Ohio farmers. The respondents were asked to check *all* safety equipment used on the farm at the time of the study. The respondents were provided a list of nine safety devices commonly used to prevent farm accidents and the findings are presented in Table 11. The 1982 sample data are contrasted when possible with comparable information obtained in 1977 by Young and Phillips (37).

The findings presented in Table 11 show that every safety device for which we have comparable data increased in use from 1977 to 1982. The greatest increases occurred in the use of squeeze bottles filled with water for anhydrous ammonia spills and smoke detectors in farm homes. The increased use of safety devices may be a partial function of increased awareness of farm safety.

Several prevention devices such as hard hats, steel-toed shoes, and fire sensors in farm buildings are seldom used. With the exception of steel-toed shoes, full-time and part-time farmers were quite similar in types of safety devices used. Part-time farmers used steel-toed shoes much more often than full-time farmers.

SUMMARY OF DESCRIPTIVE DATA

The descriptive data revealed that slightly less than one-third of the study sample had experienced at least one farm-related accident in the previous 3 years (1980-1982). More than half the farmers who had experienced an accident indicated the accident resulted in sutures, hospitalization, loss of sight, loss of hearing, loss of limbs, or death, all of which were defined as serious injuries. Farmers who had experienced accidents reported an average of 16.1 work days lost per farm-related accident, which is much higher than the number reported in earlier research (30). The large number of lost work days supports the observation made in this study that more than half of all farm accidents resulted in serious injury. The study findings demonstrated that the major causes of farm accidents are machinery, falls, and farm animals. Data collected to assess adoption of ROPS revealed an increase in use from a previously conducted study, but the percentage of farmers using ROPS was quite small, indicating slow adoption. Farm safety equipment has also increased in use since 1977, with the greatest increases in squeeze bottles filled with water for anhydrous ammonia spills and smoke detectors in farm homes. Several types of protection devices were shown not to be widely used. Throughout the presentation of the descriptive findings, comparisons were made between full-time and part-time farmers. These analyses revealed that farming status was a very poor predictor of all the safety variables examined.

MULTIVARIATE ANALYSES OF FARM ACCIDENTS

Bivariate and multivariate parametric statistics were used to determine if any of the independent variables were significantly related to the frequency of farm accidents. The relationships were examined on a bivariate basis and in combination with all other independent variables. The principal statistics used were multiple correlation and regression analyses. These statistics were used to assess the *strength* of association between the frequency of farm accidents and to determine the *best* combination of independent variables. The best regression model was defined as the linear combination of independent variables which maximized the adjusted coefficient of determination ($\bar{R}^2$).

Most of the variables included in the analysis were measured on a continuous basis, but there were several variables evaluated in the context of dichotomous response categories (yes or no). The dichotomous response-type variables were treated as "dummy" variables in the multivariate analysis, if they were not summed to form composite indexes. The use of dummy variables is an accepted practice in correlation and regression analyses (20). It was also assumed that the categorical and the perception data produced metric level information (1, 6, 17, 18, 19) which permits the use of parametric statistics. It is basically argued that the "robustness" of parametric statistics more than adequately compensates for any measurement error. All missing data were assigned the variable mean and retained for subsequent analyses. This has been shown to be the best option when the correlations were low to moderate and the amount of missing data were low. Both of these conditions were satisfied in this study.

The frequency of farm accidents was treated as the dependent variable and the farm structure and social learning factors were treated as independent variables. The independent variables were selected for inclusion in the study because they have been shown to be significantly related to farm accidents in the existing farm safety literature and are required to test the theoretical hypotheses formulated for this study.

Multivariate Findings

The first parametric findings produced are bivariate correlation coefficients to assess the strength of association between each independent variable and the frequency of farm accidents. These findings are presented in Table 12.

While 13 of the 15 relationships were shown to be significant at the 0.05 level, the magnitude of each correlation coefficient was *very low*. The strongest correlation is 0.16, which is very weak by contemporary research standards. The interpretation of the findings must be couched in the context of the weak relationships.

The correlation findings reveal that grain farmers with more years of farming who have higher levels of perceived safety awareness tend to have a *slight* tendency to be less prone to farm accidents. Farmers who have more hired employees working on the farm, who have more agricultural education, usually farm more acres, who own a greater number and larger tractors, who use liquid application equipment on the farm, who have grain storage on the farm, who transport their own farm products to market, who are more extensively engaged in livestock farming, and who have more numerous safety devices in use on the farm tend to have a *slightly* higher probability of having farm-related accidents. Use of a combine on the farm and use of drying equipment on the farm were not significantly related to the frequency of farm-related accidents at the 0.05 level.

The correlation findings suggest that selected learning experiences associated with farming tend to very slightly reduce the number of farm-related accidents, while the scale of agriculture tends to slightly increase the frequency of accidents. Safety awareness and the presence of personal protection equipment have little effect on the incidence of farm-related accidents.

Regression analysis was used to assess the relative explanatory power of the predictive variables when all independent factors were considered simultaneously. The findings are presented in standardized partial regression coefficient form with standard error of the Beta below each coefficent:

$$
\begin{array}{lllllll}
y & = & 0.15x_1 & -\,0.11x_2 & +\,0.11x_3 & +\,0.08x_4 & +\,0.07x_5 \\
 & & (0.03) & (0.03) & (0.03) & (0.03) & (0.03)
\end{array}
$$

where:

y = Total number of farm accidents

x_1 = Number of hired laborers

x_2 = Years of farming experience

x_3 = Percent livestock farmer

x_4 = Safety equipment in use

x_5 = Use of grain storage

The regression analysis revealed that five variables were significant in reducing the unexplained variance in the dependent variable. The number of hired laborers, years of farming experience, percent livestock farmer, safety equipment in use, and use of grain storage were factors shown to be significant in reducing the unexplained variance in the number of farm accidents, but cumulatively these factors only explained 6% of the total variance. This analysis confirms the correlation findings which demonstrated very weak bivariate association between the independent variables included in the model and the number of farm-related accidents.

The parametric analyses clearly demonstrate that the independent variables included in this study are very *poor* predictors of farm-related accidents. These findings confirm suspicions that safety researchers have overstated the importance of many predictive factors by relying on frequencies and significance tests without strength of association measures. The study findings reported here suggest that the variables derived from the existing safety literature as potential explanatory factors are practically worthless as predictive factors.

Summary of the Multivariate Analyses

The multivariate findings revealed that several statistically significant relationships exist between the dependent and independent variables and that they were basically consistent with the existing literature and theoretical modeling. As farm structure factors increased in terms of size and complexity, farm accidents tended to slightly increase. As farming experience increased, accidents tended to slightly decrease. All of these findings are basically consistent with the accident findings noted in the literature review section of this report and with the research hypotheses.

The only exceptions to the research expectations were type of farming operation and experience in farming. Previous research findings revealed no significant relationship between type of farming operation and accidents, while the study reported here demonstrated that livestock farmers tended to have slightly more accidents than other types of farmers. Grain farmers were also shown to have slightly fewer accidents than other farmers. Another finding which deviates from previous research is for years farming. Stout and Darbee (35) discovered that experience tended to be related to the incidence of accidents in a positive manner. The opposite was noted in this study. It is possible that the emphasis placed on very serious accidents in the Stout and Darbee study would explain the apparent differences in findings.

The major finding from the multivariate analysis is the relative *lack* of explanatory power of the 18 independent variables included in the analysis. Only 6% of the variance in the dependent variable was explained using the factors employed in the study. This finding means that the significant relationships observed in the study are of little substantive meaning in terms of predicting farm accidents.

TABLE 12.—Zero Order Correlation Coefficients for Frequency of Farm Accidents and Selected Independent Variables (N = 918).

Independent Variable	Correlation Coefficient
Years of Farming	−0.11*
No. of Hired Laborers Working on Farm	0.16*
Agricultural Education	0.08*
Acres Usually Under Cultivation	0.10*
No. of Tractors Owned	0.10*
Tractor Size	0.06*
Use of Combine	0.04
Use of Drying Equipment	0.03
Use of Liquid Application Equipment	0.11*
Use of Grain Storage	0.09*
Transportation of Farm Products	0.07*
Grain Farmer (%)	−0.07*
Livestock Farmer (%)	0.11*
Safety Equipment in Use	0.09*
Safety Awareness	−0.06*

*Significant at the .05 level using a two-tailed test.

SUMMARY AND CONCLUSIONS

The findings basically revealed that a substantial number of farmers had experienced farm-related accidents in the preceding 3-year period. Almost one-third of all study respondents reported at least one farm-related accident. Such a frequency of farm accidents is evidence that a safety problem exists for Ohio farmers. The problem takes on more serious meaning when one considers that more than half of all reported accidents were serious using our definition of the term.

While the study findings produced many interesting and useful observations about the incidence of farm accidents, contributing conditions to the accidents, and safety devices in use, the multivariate analyses revealed that the commonly stated explanations of farm-related accidents have little utility for predicting frequency of farming accidents in Ohio. While the parametric findings demonstrated that several independent variables were significantly related to the number of farm-related accidents, the magnitude of the coefficients demonstrated that the variables were practically *useless* in predicting the number of accidents. Explanatory variables are outside the model. Even farming status (full-time and part-time farming) which is a major farm structure variable was shown to be of little consequence in understanding farm-related accidents.

The major conclusion drawn from the study is that the state of knowledge about farm-related accidents in Ohio is not as far advanced as the existing literature suggests. Identification of significant differences among variables is of little utility if the strength of association is quite low. While the findings are basically consistent with the existing literature in terms of identified significant relationships, it should be noted that the strength of the relationships is practically nonexistent. Little confidence can be placed in the predictions from the derived model.

The findings strongly suggest that new avenues of empirical investigation should be undertaken in the area of farm accidents. Factors which have been examined to date and advanced as predictive variables in the literature were shown to be of little importance in Ohio. Future research should consider alternative explanatory models such as the ecological factors associated with accidents, timing of accidents, psychosocial orientations, and fatigue. Particular attention should be focused on exposure to risk via long hours of continuous farm work and use of farm equipment without appropriate safety devices. Consideration should also be given to the age and condition of the farm machinery and how the machinery is being used. Reliance on traditional variables to explain farm-related accidents will probably result in less useful model building. Prevention programs couched in such models will also probably have little influence on accident rates.

Farm-related accidents are complex phenomena to understand and will require more sophisticated models than have heretofore been developed. It is certain that reliance on social learning factors and farm structure variables such as those evaluated in this study should *not* be used to guide the development of prevention programs in Ohio.

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