FATAL OHIO FARM TRACTOR ACCIDENTS

An Abstract of a Thesis

Presented in Partial Fulfillment of the Requirements for the Degree Master of Science

by

Walter Robert McClure, B.Agr.E.

The Ohio State University
1961

Approved by

[Signature]
Advisor
Department of Agricultural Engineering
FATAL OHIO FARM TRACTOR ACCIDENTS

Abstract

Fatal farm tractor accident reports were analyzed to establish the most desirable design changes and/or educational efforts for improved safety. Recommendations encouraged the development of crushproof tractor cabs, improved operator location relative to the implement, and redirected educational efforts.
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ACKNOWLEDGMENTS

This study was sponsored by the Ohio Agricultural Experiment Station as project State 362. My project advisers, E. J. Lamp and W. H. Johnson were constant sources of advice and encouragement. W. E. Stuckey's experience in the field of farm safety was also quite helpful. My wife Doris also deserves special thanks for her patience in typing and assembling the manuscripts.

A number of people contributed in making the tractor survey a success. E. T. Shaudy assisted in planning the survey. James Url helped conduct the telephone interviews. C. H. Weaver directed the punch card work and advised the statistical analysis. Several county agents assisted in making local arrangements for the telephone interviews. Agricultural Stabilization Committee offices provided the lists of farmers from which samples were drawn. The farmers who provided the survey information deserve special thanks. Other graduate students and staff members of the Department of Agricultural Engineering provided a number of helpful ideas and encouragement.
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INTRODUCTION

The development of the farm tractor as a prime mover and power source for various agricultural implements has been an important factor in the increased labor efficiency of agricultural production in the United States during the past half century. Engineering effort has developed the tractor into a machine that is today far more efficient, more versatile, more comfortable, and more easily operated than its earlier counterpart. Whether it is a safer machine, however, is open to question.

No one concerned with American agriculture can take much pride in its safety record. In 1958, farming had the third highest death rate among major industries, and the highest total number of deaths (approximately 3300).¹ It is four times safer to work in an industrial manufacturing plant than it is to work on an American farm.²

Fiske,³ reporting National Safety Council statistics, stated that nearly 1200 of the estimated 1300 fatal accidents involving

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¹C. J. Steinbrunner, "Safety--by Education or Regulation" (paper 60-114 presented at the Annual Meeting of the American Society of Agricultural Engineers, Columbus, Ohio, June, 1960).

²Kenneth V. Fiske, "The Cost and Extent of Farm Machinery Accidents" (paper 60-110 presented at the Annual Meeting of the American Society of Agricultural Engineers, Columbus, Ohio, June, 1960).

³Ibid.
farm equipment in 1969 involved the farm tractor. During the
decade of the 1950's, the total number of American tractor fatalities
approximately doubled, while farm tractor population increased only
40 per cent, and the number of farm residents dropped 20 per cent.
Thus, with this increased exposure to accidents, the typical American
farm resident today has about two and one-half times the probability
of meeting with a fatal tractor accident as he had in 1950.

The extent of accidents directly involving farm tractors in
Ohio is outlined in Table I. Based on these statistics, if an Ohio

<table>
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<th>Ohio Yearly Average 1956-1960</th>
<th>Fatal Accidents</th>
<th>Non-fatal Accidents</th>
</tr>
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<tr>
<td>Total Number</td>
<td>42</td>
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</tr>
<tr>
<td>Per 10,000 Farm Operators b</td>
<td>2.6</td>
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<td>Per 10,000 Tractors b</td>
<td>2.0</td>
<td>66</td>
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<td>4.2</td>
<td>139</td>
</tr>
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<td>0.5</td>
<td>17</td>
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*Estimated from: R. H. Behar and W. E. Stuckey, "Accidents to
Farm People--3501 Reasons for a Safety Program," Extension Bulletin
365, Agricultural Extension Service, The Ohio State University,
Columbus, Ohio, 1958. Non-fatal accidents were defined as those
requiring care of a physician, or resulting in loss of one-half
day or more time.

*Calculated from 1960 estimates based on: U.S. Department of
Commerce, Bureau of the Census, 1964 Census of Agriculture, Volume 1,

*Based on author's 1960 survey of farm tractor owners.
farmer is assumed to farm for a period of forty years, there is over a one per cent chance that he will experience a tractor fatality, and a forty per cent chance that he will experience a non-fatal tractor accident.

There are two general approaches to the reduction of accidents involving any machine. Attempts may be made to educate machine users to operate the existing equipment safely, or safety features may be designed and built into the machine itself. Considerable educational effort has been directed toward reducing farm tractor accidents. However, the magnitude and diversity of American agriculture permits little or no special training or supervision of most farm tractor operators (when compared with the operators of comparable industrial machines). Therefore, the approach of designing safety into the tractor would obviously be preferable, if it could be accomplished at reasonable cost and without seriously impairing the functions of the machine.

A large number of variables are associated with every farm tractor accident. These include the nature of the accident, and the various human, environmental, and machine factors\(^4\) which combine to cause the accident. The extent of each type of accident, and the extent of the factors and interactions of factors involved in the

\(^4\) L. W. Knapp, "Epidemiological Study of Tractor Accidents" (paper 60-l11 presented at the Annual Meeting of the American Society of Agricultural Engineers, Columbus, Ohio, June, 1960).
accidents should be a basis for planning engineering and educational efforts toward reducing the number of tractor accidents. This study was an attempt to determine and evaluate some of these variables as they were related to fatal farm tractor accidents in Ohio.


BACKGROUND

Review of Previous Studies

Previously published studies within the area of farm tractor safety can be placed into two basic categories. One type of study involves gathering certain information about past tractor accidents and organizing these data in some sort of statistical presentation for use in tractor safety educational work. The work of Fiske\(^1\) is one example of this approach.

The second type of study involves the theoretical and/or experimental analysis of certain aspects of tractor or human dynamics in an attempt to show principles of safer tractor design. A large number of studies in this area have been conducted. McKibben,\(^2\) Worthington,\(^3\) and Sack\(^4\) have analyzed tractor dynamics.

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\(^1\)Fiske, op. cit.

\(^2\)H. G. McKibben, "The Kinematics and Dynamics of the Wheel Type Farm Tractor," *Agricultural Engineering* 8:18, 39, 58, 90, 119, 155, 187, January-July, 1925.


Corliss, and Dupuis have studied some of the psychological and physiological effects of tractor operation. A number of other researchers have conducted studies directly or indirectly related to tractor safety. These include Liljedahl, Ryan and Terry, and Lamourie. The development of power steering and improved operator seating comfort have probably also contributed indirectly to safer tractor operation.

Background of This Study

In 1956 a series of farm tractor safety demonstrations were planned by the Ohio Farm Safety Committee and Extension specialists. At this time it was realized that planning such activities for maximum effectiveness required rather detailed information concerning the nature and extent of farm tractor accidents, and that only limited data of this sort were available.


To help overcome this deficiency, a project was initiated to gather information about fatal tractor accidents occurring in Ohio.\textsuperscript{10} This project, conducted in cooperation with an insurance company, has provided data on nearly every fatal accident reported since January 1, 1936. Accidents were reported through a newspaper clipping service. Following each accident, a questionnaire was sent to a local insurance claims agent who personally interviewed those familiar with the accident circumstances and completed the questionnaire. Through 1960, such reports were received on 212 fatal accidents directly involving the farm tractor.

Original plans were to use the accident information only as a basis for educational efforts. However, in 1958 a study conducted by Holdren\textsuperscript{11} suggested that certain tractor design features, such as weight-to-horsepower ratio, front wheel arrangement, fenders, etc. were related to certain types of accidents.

The Holdren study was inconclusive, however, because of the small sample studied, and because information was not available for comparing the accident distributions by various classifications with the overall tractor population distribution. The present study was organized to better establish these comparisons and provide a more thorough analysis of all the accident reports.

\textsuperscript{10}Project was under the leadership of W. E. Stuckey, Extension Safety Specialist, The Ohio State University.

\textsuperscript{11}Richard D. Holdren, "Comparison of Design Features of 96 Tractors Involved in Fatal Accidents," Department of Agricultural Engineering Special Problem Report, The Ohio State University, 1958.
OBJECTIVES

The primary objectives of this study were as follows:

1. To establish relationships, if any, between tractor design characteristics and fatal accidents.

2. To determine possible modifications to tractor design, which on the basis of accident records would improve tractor safety.

3. To organize useful data concerning the nature and extent of fatal tractor accidents.

4. To explain seemingly abnormal accident frequencies by theoretical analysis or experimentation.

A secondary objective was to characterize the Ohio farm tractor population by make, model, horsepower, wheel arrangement, and other classifications.
PROCEDURE

Survey of Ohio Farm Tractors

At the beginning of the study, it was realized that some detailed information about the tractor population in Ohio would be needed before any definite conclusions could be drawn from the accident analysis. Fair comparisons can be made only if some attempt is made to evaluate a number of the variables which may have an effect upon accident frequency and may not be homogeneous throughout the entire tractor population. The following items were believed to be the major unknown factors:

1. Distribution of Ohio tractors according to make, model, wheel type, and total and front end weight-to-power ratio.
2. Hours of annual usage.
3. Type of terrain on which the tractors were normally operated.
4. Frequency of operation under hazardous conditions.
5. Wheel spacing characteristics.

Since only very limited information was available on the above items, it was apparent that only a survey of Ohio farmers could provide the needed information with a reasonable degree of reliability.
It was decided that the technique of a telephone would best provide the needed accuracy at reasonable cost. A mimeograph publication "Telephone Interviewing"\(^1\) was used as a guide in planning the telephone survey.

Although a sampling rate of one-fourth per cent was suggested as being adequate for the purposes of this study, it was decided by increasing this rate to one-half per cent in the southeastern area (because of the relatively low tractor population in this area) and to one-third per cent in the other areas better information would be obtained with very little, if any added cost other than the time of the interviewer. Four counties were selected for sampling at random from each of the four areas. The large number of counties was selected to reduce the effect of any unusually strong dealerships or area preferences for a particular make of tractor. The number of farmers to be interviewed in each county was determined from 1960 estimates of tractor population and number of farms projected from the 1950 and 1954 Census of Agriculture figures.

The names of farmers to be interviewed were selected at random from the local county Agricultural Stabilization Committee files. In counties where local calls from the county seat telephone

\(^1\)Alan H. Mitchell, "Telephone Interviewing," Department of Agricultural Economics and Rural Sociology Department Mimeograph Series No. A-E. 379, Ohio Agricultural Experiment Station, Wooster, Ohio, 1957.
exchange could reach a minimum of approximately one-fourth of the
farmers in the county, only farmers having telephones which could
be reached without toll from the county seat exchange were included
in the sample. In one county (Auglaize) it was necessary to make
calls from two exchanges to obtain the necessary coverage.

A survey form was designed to permit quick recording of the
data and to facilitate the coding for the punch cards. The form
included questions pertaining to additional information not neces-
sarily related to the accident study but which were included as a
matter of convenience so that the information might be available
if and when needed.

Arrangements for the use of telephones in the counties
sampled were made through the local county agent's office. In
most counties the county agent's office supplied the telephone,
however private homes and other agencies also provided telephones.

In most counties, the interviews were conducted in the evening
after the office was closed. This reduced the requirement for
call-backs (farmers are in or near the house more during the evening
than during the daytime) and avoided tying up office telephone
lines and other facilities during business hours. Calling was
discontinued at about 9:30 P.M. In most counties it was possible
to complete the desired number of interviews in the allotted time.
In a few counties, the 9:30 deadline forced a slight reduction (in
most cases only one or two) in the number of interviews planned.
Cooperation on the survey was excellent. Most farmers seemed quite willing to provide the information desired. Only 1.5 per cent of the farmers contacted refused to cooperate. If a farmer refused or could not be contacted after three attempts at least one hour apart, his name was dropped and replaced from a list of replacement names which also were selected at random.

The survey information was coded for punch cards. Wherever possible, the same coding was used for the survey information as was used for fatality reports. In addition to the information appearing directly on the survey form, a total weight-to-horsepower ratio and a front end weight-to-horsepower ratio were calculated for each tractor (with added weight included) and included in the coding.

Punch card sorting and tabulating equipment was used to obtain numerous frequency breakdowns of the survey data by various classifications. Certain summations were also computed with the tabulating equipment so that category means could be calculated.

In order to facilitate the interpretation of certain data, it was necessary to establish dependence or independence among certain population parameters. This was achieved through the use of a standard chi-square test.2

Accident Reports

The study began with a perusal of the Holdren report and all the accident reports gathered prior to 1960. This was done to gain a general familiarity with the accidents so that the analysis might be planned in an efficient manner. The classical equations of tractor stability as presented by McKibben and later by Worthington were also reviewed.

Organization of the data began with the development of an "Accident Summary Sheet." This sheet was developed to facilitate the organization of the accident information under more uniform standards and to facilitate the punch card coding. The information regarding each accident was organized on the summary sheets to include obvious information such as ages, make and model of tractor, county, etc., classifications according to accident type and cause of death, determinations of apparent human, machine, or environmental factors, or a combination of factors.

The data were coded for punch card equipment by arbitrarily assigning numbers to most items within the columns and using logical groupings for the columns. In certain cases, such as for years, months, hour of day, and ages of operators and victims the obvious numerical sequences were used. Tractor models within each make were coded by their Nebraska test maximum corrected drawbar horsepower, the figure being rounded to the nearest horsepower. Counties were grouped into four 20-county "areas".
corresponding to the four Extension districts. Counties within each area were coded separately.

Tabulation consisted of sorting the cards into a number of different arrangements, such as accident type, make and model of tractor, age of victim, etc., and making printed copies of all the information on all the accidents according to the various arrangements. This was done in preference to making counts on all possible items because of the difficulty in determining ahead of time the exact counts that would be needed, and also because of the relatively small number of items in many of the categories. By use of the printed arrangements, almost any additional count found necessary could be completed in a few minutes. However, a number of the more obvious counts of items within particular categories were made with the tabulating equipment.

The punch card tabulations were studied for significant relationships of all types. Particular attention was directed toward relationships involving the type of accident, and the operating circumstances preceding the accident situation.

**Accident and Population Comparisons**

The approximate distributions of Ohio farm tractors by the design parameters of weight-to-power ratio, front end weight-to-power ratio, drawbar horsepower, and front end arrangement were determined by the telephone survey. Likewise, most of the
accident reports contained sufficient information concerning the
make, model, and front end arrangement of the tractors involved in
accidents that precise frequency distributions could be determined
by horsepower and front end arrangement. Unfortunately, only a few
reports included any estimate of the additional weight carried by
an accident tractor. Thus it was necessary to use the model average
weights determined by the survey in estimating accident frequency
distributions by weight-to-power ratio and front end weight-to-
power ratio. A standard chi-square goodness of fit test \(^3\) was used
to determine significant differences between accident and population
distributions for each of the parameters mentioned and for the major
accident types.

The findings of certain accident and population frequency
comparisons prompted an investigation of the theory of lateral
tipping. A mathematical analysis determined equations appli-
cable for a simple lateral tipping situation. The tipping angles
of some current production tractors were calculated using these
equations.

\(^3\)Ibid., pp. 64-66.
RESULTS

Survey of Ohio Farm Tractors

Four of the tractor design parameters suspected to be related to tractor accidents were drawbar horsepower, weight-to-horsepower ratio, front end weight-to-horsepower ratio, and wheel arrangement. The tables below indicate the findings of the survey with respect to these parameters.

TABLE II

DISTRIBUTION OF SURVEY TRACTORS BY DRAWBAR HORSEPOWER

<table>
<thead>
<tr>
<th>Drawbar Horsepower</th>
<th>Tractors Indicating Drawbar Horsepower</th>
<th>Adjusted Number</th>
<th>Adjusted Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Number</td>
<td>46.0</td>
<td>46.0</td>
</tr>
<tr>
<td>10-19</td>
<td>53</td>
<td>322.1</td>
<td>322.1</td>
</tr>
<tr>
<td>20-29</td>
<td>357</td>
<td>201.5</td>
<td>201.5</td>
</tr>
<tr>
<td>30-39</td>
<td>218</td>
<td>137.5</td>
<td>137.5</td>
</tr>
<tr>
<td>40-49</td>
<td>146</td>
<td>21.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Over 50</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>796</td>
<td>732.0</td>
<td>732.0</td>
</tr>
</tbody>
</table>

*Tractor numbers were adjusted to compensate for the higher sampling rate in southeastern Ohio.
### TABLE III

**DISTRIBUTION OF SURVEY TRACTORS**
**BY POUNDS TRACTOR WEIGHT PER HORSEPOWER**

<table>
<thead>
<tr>
<th>Pounds per Horsepower</th>
<th>Total Number</th>
<th>Adjusted Number</th>
<th>Adjusted Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 100</td>
<td>13</td>
<td>11.1</td>
<td>1.5</td>
</tr>
<tr>
<td>100-119</td>
<td>55</td>
<td>47.6</td>
<td>6.5</td>
</tr>
<tr>
<td>120-139</td>
<td>229</td>
<td>206.7</td>
<td>28.7</td>
</tr>
<tr>
<td>140-159</td>
<td>155</td>
<td>142.0</td>
<td>19.5</td>
</tr>
<tr>
<td>160-179</td>
<td>225</td>
<td>210.9</td>
<td>28.9</td>
</tr>
<tr>
<td>180-199</td>
<td>96</td>
<td>79.0</td>
<td>10.8</td>
</tr>
<tr>
<td>200-219</td>
<td>23</td>
<td>20.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Over 220</td>
<td>9</td>
<td>9.0</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>792</strong></td>
<td><strong>729.7</strong></td>
<td><strong>99.9</strong></td>
</tr>
</tbody>
</table>

### TABLE IV

**DISTRIBUTION OF SURVEY TRACTORS**
**BY FRONT END WEIGHT, POUNDS PER HORSEPOWER**

<table>
<thead>
<tr>
<th>Front End Pounds per Horsepower</th>
<th>Total Number</th>
<th>Adjusted Number</th>
<th>Adjusted Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 35</td>
<td>108</td>
<td>102.9</td>
<td>14.1</td>
</tr>
<tr>
<td>35-39</td>
<td>170</td>
<td>158.5</td>
<td>21.7</td>
</tr>
<tr>
<td>40-44</td>
<td>262</td>
<td>240.1</td>
<td>32.9</td>
</tr>
<tr>
<td>45-49</td>
<td>189</td>
<td>171.9</td>
<td>23.6</td>
</tr>
<tr>
<td>Over 50</td>
<td>63</td>
<td>58.3</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>792</strong></td>
<td><strong>729.6</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
Over two-thirds (67 per cent) of the survey tractors were of the tricycle type. Twenty-two per cent were of the wide-front-wheel, utility (low clearance) type. Nearly ten per cent of the tractors were equipped with wide front wheels, but were otherwise essentially the same as the equivalent tricycle model. The remaining one per cent of the tractors surveyed were either crawler or four-wheel-drive ("Jeep") type vehicles.

Three questions were asked tractor owners in an attempt to determine indications of varying exposure of tractors to accident situations. Most obvious was to ask an estimate of the hours of annual use. Thirty-four per cent of the tractors, where this was indicated, were estimated to have been used less than 300 hours per year. Forty-four per cent were used from 300 to 600 hours, and twenty-two per cent were used over 600 hours a year.

Two questions were then asked to provide an estimate of the operating conditions for the tractor. The farmer was first asked to estimate the general topography on which the tractor was normally operated. Based on the owners' opinions, twelve per cent were operated on "flat" land, forty-eight per cent on "fairly level" land, thirty-three per cent on "rolling" land, and the remaining seven per cent were operated in "hilly" conditions.

The second question asked of the farmer was to estimate the relative frequency that his tractor was operated under "hazardous" conditions, such as on steep hillsides, near ditchbanks or embankments, or other dangerous situations. Forty-five per cent of the
tractors were said to be used under such conditions "rarely" or "never." Forty-one per cent were "occasionally" operated under some hazardous condition, while fourteen per cent were "frequently" subjected to such dangers.

It was necessary to have some estimate of dependence among the various parameters established in the survey. For example, if an abnormally high number of tractors within a certain horsepower range were found to be "frequently" operated under hazardous conditions, it would be reasonable to expect a higher accident rate among tractors within this range.

Table II presents a comparison of the major parameters considered. In most cases a contingency table was established for the two parameters being compared and a chi-square test of independence applied. In some instances, dependence was obvious so application of the test was unnecessary. Also, in a few instances dependence was assumed from widely differing group means.

Accident Reports

Two general methods were used to classify all accidents. The first involved classification by the condition which led to the death of the victim. Classifications used under this system were as follows:
1. Tractor upset backwards.
2. Tractor upset sideways.
3. Tractor upset—forward or unknown.
4. Victim was thrown or had fallen from tractor or implement.
5. Victim was killed by collision impact.
6. Victim was struck by the tractor while dismounted.
7. Other.

The second method of classification attempted to classify accidents by the nature of the tractor operation which preceded the accident situation. Categories used in this method were as follows:

1. Tractor was driven into a ditch or off an embankment.
2. Tractor operator attempted to negotiate excessively sloping ground.
3. Tractor was operated at high speed for the conditions involved.
4. Tractor collided with another vehicle or object.
5. Tractor was pulling under abnormal circumstances.
6. Tractor was parked.
7. Other.
8. Circumstance unknown.

Table V shows the accident frequencies by each of these methods of classification.

The accidents which involved operation on sloping ground were nearly equally divided in three sub-classes. Fourteen occurred while the tractor was being driven across the slope. Another fourteen occurred with the tractor going up-slope, and thirteen happened while the tractor was going down the slope.

Of the 51 accidents which involved speed of operation only five were caused through loss of control from speed alone. Eighteen happened when the tractor struck an obstruction (rock, stump, etc.) at high speed, and eight occurred while the tractor
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ditch</td>
<td>3</td>
<td>26</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>58</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>2. Slope</td>
<td>7</td>
<td>20</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>41</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>3. Speed</td>
<td>16</td>
<td>14</td>
<td>1</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>35</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>4. Collision</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>23</td>
<td>6</td>
<td>1</td>
<td>35</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>5. Pulling</td>
<td>15</td>
<td>1</td>
<td>2</td>
<td>23</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>6. Parked</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>12</td>
<td>1</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>7. Other</td>
<td>1</td>
<td>9</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>23</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>8. Unknown</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>29</strong></td>
<td><strong>64</strong></td>
<td><strong>8</strong></td>
<td><strong>40</strong></td>
<td><strong>23</strong></td>
<td><strong>9</strong></td>
<td><strong>192</strong></td>
<td><strong>9</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Per cent</strong></td>
<td><strong>14</strong></td>
<td><strong>40</strong></td>
<td><strong>4</strong></td>
<td><strong>19</strong></td>
<td><strong>11</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

was turning at high speed.

Collisions were of two distinct types, the most common being where the tractor was struck by another vehicle moving at relatively high speed (23 accidents). The other twelve accidents involved the tractor striking a slowly moving or stationary object.

Table VI indicates the distribution of accidents by place of occurrence. Certain relationships were also noted between place
TABLE VI

PLACE ACCIDENT OCCURRED

<table>
<thead>
<tr>
<th>Place</th>
<th>Number of Accidents</th>
<th>Per Cent of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Field</td>
<td>88</td>
<td>41.5</td>
</tr>
<tr>
<td>2. Public highway</td>
<td>42</td>
<td>19.8</td>
</tr>
<tr>
<td>3. Farmyard</td>
<td>34</td>
<td>16.0</td>
</tr>
<tr>
<td>4. Farm lane</td>
<td>25</td>
<td>11.8</td>
</tr>
<tr>
<td>5. Other</td>
<td>23</td>
<td>10.4</td>
</tr>
</tbody>
</table>

and some types of accidents. Eleven of thirteen (85 per cent) sideways upsets which occurred on a cross-slope were in the field. Twenty-one of twenty-nine (73 per cent) backwards upsets were in the field. Thirteen of seventeen (76 per cent) of the upsets caused by speed were in the farm lane or on the highway, however, seven of eleven (64 per cent) accidents where the victim fell, because of hitting a rock or other obstruction, were in the field. Seven of twelve (58 per cent) of the non-highway type collisions occurred in the farmyard.

Figure 2 compares the age distributions of the accident victims with Ohio farm operators. It may be observed that the accident rate of farmers over age 60 is approximately 40 per cent higher than what might be expected from the number of farm operators in this age group. Older farmers had particularly high accident rates in accidents involving, (1) ditches, (2) collisions, and (3) pulling.
Youthful victims were mainly involved in accidents where the victim was thrown or had fallen (23 of 40 were under age eighteen) and accidents where the victim had ridden on the tractor (28 of 39 tractor riders killed were under age sixteen). Where speed was involved, 10 of 21 victims and 13 of 21 operators were under age twenty.

Table VII shows the extent of the major human, environmental, and machine factors that were apparent contributing causes of the accident. Seventy-nine per cent of the accidents had one or more human factors involved. Environmental and machine factors were involved in fifty-eight and thirty-four per cent of the accidents respectively.

Other accident data are presented in figures 3, 4, and 5. These include accident time variations, position of the victim relative to the tractor, and equipment operated by the accident tractor.
### TABLE VII

**EXTENT OF HUMAN, ENVIRONMENTAL, AND MACHINE FACTORS IN ACCIDENTS**

<table>
<thead>
<tr>
<th>Percentage of All Accidents</th>
</tr>
</thead>
</table>

**A. Human factors (79%)**

1. Obviously poor judgment or ignorance to danger... 44
2. Hurry ........................................ 21
3. Inattention .................................... 21
4. Inexperience .................................. 12
5. Physical condition of operator or victim .......... 9

**B. Environmental factors (58%)**

1. Operation on sloping ground .................... 26
2. Ditches or embankments ........................ 24
3. Public highways ................................ 17
4. Holes, rocks, stumps, other low obstructions ..... 17
5. Mud, soft conditions ............................ 8
6. Slippery conditions ............................ 5

**C. Machine factors (34%)**

1. Trailing machinery .............................. 12
2. Apparently inadequate seating, fenders .......... 10
3. Mechanical failure ............................ 7
4. Improper hitching ............................. 7
5. Instability caused by mounted equipment ......... 6
Accident and Population Comparisons

Comparisons of accident-to-population distributions for the tractor design parameters of weight-to-horsepower ratio, front end weight-to-horsepower ratio, drawbar horsepower, and front wheel arrangement were made. Figures 6 through 9 show the comparisons of these categories for all accidents, and for specific types of accidents where a significant (α = .05 level) difference occurred.

Figure 6 indicates that, while there was a significant variation in accidents when considering weight-to-horsepower ratio, the variation was irregular. It is believed that much of this variation stems from the fact that it was necessary to use model averages in computing the weight-to-horsepower ratio of the tractors involved in the accidents, while the population distribution involved an individual calculation for each tractor. Many of the models with an average in the 120-140 pounds per horsepower range actually included many individual tractors in the next higher or lower ranges (because of added weight). However, there is an indication that tractors of low weight-to-horsepower ratios were involved in more backwards upsets. No significant variations were noted in comparing weight-to-horsepower ratios for other accident types.

No significant variations were noted in comparing front and weight-to-horsepower ratio or drawbar horsepower for most accident types. Figure 7 shows a definite increase in the thrown or fallen type accidents with increased front end weight-to-horsepower ratio.
Figure 8 indicates that no tractor above 40 drawbar horsepower was involved in a backwards upset.

As indicated in Figure 9, wide-front-wheel tractors were involved in a significantly higher proportion of all accidents, backwards upsets, and thrown or fallen type accidents than might be expected. However, a significantly higher percentage of these tractors was operated under the more hazardous environmental conditions.

**Lateral Tipping Equations**

Most farmers and probably most engineers have assumed the wide-front-wheel tractor to be of inherently superior lateral stability to the tricycle type tractor. There was, however, no evidence of the validity of this assumption found in this study. This lack of evidence prompted the following analysis which examined the situation of simple lateral tipping more closely than previously reported studies.

Figure 1 indicates the critical points involved in lateral tipping. G represents the tractor center of gravity. C is the point of contact of the downhill rear wheel with the ground. B is the point of ground contact for the downhill front wheel of a tricycle tractor, while D is the corresponding point on a wide-front-wheel tractor. The front axle of the wide-front-wheel tractor is attached to the frame at point A, and pivots within limits at that point.
Fig. 1.—Lateral Tipping of a Tractor
Lateral tipping of the tricycle tractor occurs around axis BC. With the wide-front-wheel tractor, initial tipping will occur about axis AC. Tipping will continue about this axis until the limit of front axle pivot is reached. At this point CD becomes the axis of rotation.

The tractor becomes unstable when the center of gravity G passes to the down-slope side of the applicable axis of rotation. The angle \( \phi \) at which tipping begins under static conditions may be calculated by simple geometry and trigonometry. For the axes considered:

1. about BC
   \[ \tan \phi = \frac{a_1b_2 + (a_2 - a_1)b_3}{a_2(c_1 + c_2)} \]

2. about AC
   \[ \tan \phi = \frac{a_1b_2}{a_2c_1 + a_1c_2} \]

3. about CD
   \[ \tan \phi = \frac{bg}{c_1 + c_2} \]

Table VIII compares the values of \( \phi \) using dimensions found on two current production tractors, the Massey-Ferguson 35 Diesel and 85 High Clearance (the existence of a tricycle model comparable to the 35 Diesel is hypothetical).

Worthington\(^1\) essentially considers the front axle to be rigid, thus using equation (3), which indicates a more favorable stability

\(^1\)Worthington, op. cit.
TABLE VIII
TRACTOR TIPPING ANGLES CALCULATED

<table>
<thead>
<tr>
<th>Dimension (inches)</th>
<th>M-F 30 Diesel</th>
<th>M-F 65 Hi-Cw.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>49</td>
<td>55</td>
</tr>
<tr>
<td>b</td>
<td>72</td>
<td>28</td>
</tr>
<tr>
<td>b2</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>b3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>e1</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>e2</td>
<td>21.5</td>
<td>29.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ϕ (degrees)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) about BC</td>
<td>33.6</td>
</tr>
<tr>
<td>(2) about AC</td>
<td>39.7</td>
</tr>
<tr>
<td>(3) about CD</td>
<td>42.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>α (degrees)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured</td>
<td>12.8</td>
</tr>
<tr>
<td>(9) α max.</td>
<td>5.3</td>
</tr>
</tbody>
</table>

condition for wide-front-wheel tractors than does equation (2). The validity of equation (2) depends on the amount of pivot permitted the front axle about point A.

Referring again to Figure 1, View 3 shows the normal view of plane ABC, and View 4 indicates the end view of line AC. The tractor rotates about this axis through the angle α permitted by the stops on pivot A. The center of gravity moves to the new position G'. Thus, approximately (α is small):

\[ G' = G \sin \alpha \]
When the axis of rotation shifts to OD, the tractor will be statically unstable if

\[(5) \quad \mathcal{H} > b_2 \cos \phi - (c_1 + c_2)\sin \phi\]

(actually, the horizontal component of \(\mathcal{H}\) perpendicular to axis OD should be considered, however in most instances encountered this component approximately equals \(\mathcal{H}\).) Substituting:

\[(6) \quad \mathcal{H} \sin \alpha > b_2 \cos \phi - (c_1 + c_2)\sin \phi\]

Thus, the maximum value of \(\alpha\) permitted for the tractor to become statically stable is determined by:

\[(7) \quad \sin \alpha_{\text{max}} = \frac{b_2 \cos \phi - (c_1 + c_2)\sin \phi}{\mathcal{H}}\]

\(\mathcal{H}\) may be evaluated by vector analysis.\(^2\) Considering \(AG\) and \(AG\) as vectors separated by the angle \(\theta\):

\[
\frac{|\mathcal{H} \times \mathcal{C}|}{|\mathcal{H}|} = |\mathcal{H}| |\mathcal{C}| \sin \theta
\]

\[
|\mathcal{H} \times \mathcal{C}| = |\mathcal{H}| |\mathcal{C}| \sin \theta = \mathcal{H}
\]

Continuing, using standard vector notation and the dimensions in Figure 1:

\[
\mathcal{H} = a_1 \hat{T} + c_1 \hat{F}
\]

\[
\mathcal{C} = a_2 \hat{T} + b_1 \hat{J} + c_2 \hat{F}
\]

\[
\mathbf{AD} \times \mathbf{AC} = \begin{vmatrix}
1 & 1 & 1 \\
a_1 & a_2 & c_2 \\
0 & b_2 & c_2
\end{vmatrix} = -b_2 c_1 + (a_2 c_1 - a_1 c_2)^2 + a_1 b_2
\]

\[
|\mathbf{AD} \times \mathbf{AC}| = \sqrt{(b_2 c_1)^2 + (a_2 c_1)^2 - 2a_1 a_2 c_1 c_2 + (a_1 c_2)^2 + (a_1 b_2)^2}
\]

\[
|\mathbf{AC}| = \sqrt{a_2^2 + b_2^2 + c_2^2}
\]

\[
\therefore \quad FG = \sqrt{\frac{(b_2 c_1)^2 + (a_2 c_1)^2 - 2a_1 a_2 c_1 c_2 + (a_1 c_2)^2 + (a_1 b_2)^2}{a_2^2 + b_2^2 + c_2^2}}
\]

Thus, substituting into equation (7):

\[
(9) \quad \sin \alpha_{\text{max}} = \frac{b_2 \cos \phi - (a_1 + a_2) \sin \phi}{\sqrt{(b_2 c_1)^2 + (a_2 c_1)^2 - 2a_1 a_2 c_1 c_2 + (a_1 c_2)^2 + (a_1 b_2)^2}}
\]

For the tractors compared in Table VIII, the measured value of \(\alpha\) was considerably larger than \(\alpha_{\text{max}}\); therefore equation (2) for the maximum angle of lateral stability would apply. Note that the number of degrees advantage offered by equation (2) over the tricycle tractor were less than three-fourths the advantage claimed when equation (3) is applied.

If the front axle attachment (point A) were lowered (reducing \(c_2\) and increasing \(a_1\)) the advantage of the wide-front-wheel tractor would be further reduced. Likewise, moving the center of gravity rearward (increasing \(c_1\)) would also reduce the advantage of the wide-front-wheel tractor.
DISCUSSION OF RESULTS

It was readily apparent there was no one "typical" fatal tractor accident. It was possible, however, to characterize the majority of accidents by a rather small number of "typical" descriptions.

Fifty-seven per cent of all fatalities occurred when the victim was pinned beneath an overturned tractor. In over two-thirds of these instances the tractor upset sideways. Four general descriptions served to characterize 86 per cent of the upset accidents.

Thirty-five fatalities occurred when the tractor was driven into a ditch or off an embankment and upset. Perhaps half of these accidents occurred while the operator's attention was distracted by equipment he was operating. Another sizeable portion of these accidents happened while the tractor was driven at fairly high speed on a road or lane parallel to the ditch. A higher than normal percentage of older drivers (over age 60) were involved in this type of accident.

Thirty-four fatalities resulted from a tractor tipping while operated on a steep slope. These were nearly equally divided among operations going up the slope, across the slope, and
down-slope. A tractor made unstable by mounted equipment, such as a manure loader, was involved in eleven of these accidents. Only six of the thirty-four accidents occurred with an unloaded tractor.

Seventeen fatal upsets (sixteen were sideways) happened when a tractor was operated at excess speed. In five cases, control apparently was lost from speed alone, in seven the tractor struck a low obstruction, and in five the tractor tipped from centrifugal force while turning. Youthful operators were prominent in this type of accident.

The most sharply defined group of upsets were the sixteen fatalities resulting from a towing operation. Fifteen of these were backwards upsets. Muddy conditions were a factor in eleven of these accidents—in seven, the towed implement or vehicle was stuck. In thirteen of the sixteen accidents an improper hitch was involved—a chain or cable on the axle or hydraulic lift of the tractor.

Eleven per cent of all accidents were of the unique type in which the tractor was struck by a fast moving vehicle. A "typical" accident of this type involved a tractor pulling a wagon which was struck from the rear by a heavy truck on a state highway.

Nearly twenty per cent of all accidents involved the victim being thrown from the tractor. Two major categories within this type were defined, both of which involved over seventy per cent victims under age twenty. Fourteen victims, including ten under age 18 were thrown when the tractor struck a low obstruction or
turned at high speed. Ten victims, including eight under age fourteen, fell from the tractor for no apparent reason.

With the major tractor accident groups identified and characterized, the next objective was to suggest and evaluate certain methods of reducing these accident numbers. As previously mentioned, two general approaches to safety involve basically (1) making the machine safe through design, or (2) making the machine operator safe through education. Also, since all fatalities involve some sort of mishap, two additional approaches to avoiding fatalities are apparent. First, and obviously preferable, would be to avoid the mishap entirely. However, if the mishap does occur, the second approach would be to prevent injury to the victim.

Since nearly sixty per cent of the fatalities involved a tractor upset, it seemed logical to first investigate approaches for reducing these accidents. From the design viewpoint, a low center of gravity, a wide front and/or rear wheel spacing, and the use of a high weight-to-power ratio all tend to help a tractor maintain its stability.\(^1\)\(^2\) Unfortunately, each of these parameters has a definite practical limitation. There was little evidence from the accident data which indicated that tractors of a low center of gravity, or with wide front wheels were any less upset-

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\(^1\)McKibben, op. cit.

\(^2\)Worthington, op. cit.
prone. However, it should be recalled that wide-front-wheel tractors were operated more frequently on rolling or hilly land. Avoiding a weight-to-horsepower ratio of less than 140 pounds per horsepower appeared to be beneficial in reducing backwards upsets.

It is suggested that the most significant design change to avoid upsets would be to rearrange the tractor and implements so that the tractor operator could observe both his implement and his forward motion without turning completely around. With such an arrangement it appeared that one-third of all upset fatalities would not have occurred.

It was difficult to appraise the value of a device that would automatically slow or stop the engine when an unstable condition was approached. At most such a device would have been effective in preventing only fifteen to twenty per cent of the upsets.

In the event an upset could not be avoided, the use of a roll bar or crushproof cab would have been very effective in protecting the operator. A well-designed device of this type would probably have saved at least two-thirds of the upset victims from fatal injury.

Nearly twenty per cent of the fatalities involved the victim having fallen or being thrown from the tractor (in a few cases from an implement being towed). About two-thirds of these accidents occurred when the tractor was subjected to some extreme acceleration or deceleration (upward, downward, lateral, forward, or reverse)
caused by a bump, collision, or centrifugal force. This acceleration was sufficient to dislodge the victim from his position on the tractor, after which he was killed by falling under the tractor wheels (17 accidents), falling under equipment pulled by the tractor (15 accidents), or striking the ground or some object (6 accidents). In about one-fourth of these accidents the victim fell or jumped from the tractor for no apparent reason. The majority of these victims were young children.

Two obvious methods exist for keeping operators (and riders) on the tractor. First, it is most desirable to exercise care in driving, thus avoiding the accelerations that throw victims. Since this is not always done, the second alternative is to keep the operator on the tractor despite these accelerations. Seat belts are one such method. However, the use of a seat belt would destroy the operator's chances of jumping clear in the event of an upset. For this reason, the use of seat belts would be recommended only if used with a roll bar or crushproof cab.

An enclosed cab would serve to keep operators and riders on the tractor. Such cabs, complete with an air conditioning system, are now in limited use on self-propelled combines. If a cab were made to be crushproof, it would protect the operator not only from being thrown from the tractor, but from an upset as well. Seat belts used with an effective roll bar would serve the same purpose. Complete use of such an arrangement should eliminate at least three-fourths of all tractor fatalities.
If the use of a cab is not deemed practical, another design approach would be to mount implements forward of the operator and arrange his seating such that the danger of his falling under either the tractor wheel or the machinery would be minimized. Such an arrangement might eliminate two-thirds of the thrown or fallen fatalities.

Highway collisions were the third major accident group. In the majority of these accidents the tractor was struck from the rear. Short of keeping tractors off the highway, the logical approach to avoiding collisions would be to make the rear end of the tractor (or implement pulled by the tractor) readily identifiable from the rear through use of lights, characteristic paint, or other devices. In the event of a collision, the use of a crushproof cab would provide protection for the operator.

Educational efforts have logically been directed toward avoiding the mishap rather than preventing injury in the mishap. This study permitted a re-evaluation of existing efforts in tractor safety education and emphasized a number of situations which tractor operators should be trained to avoid, if possible. If certain hazardous situations cannot be avoided, the tractor operators should be trained in the best methods for safely handling these conditions.

Operation of a tractor near ditches or on steeply sloping ground should be avoided whenever possible. The use of mounted equipment (particularly manure loaders) tended to increase these
hazards, as did the necessity of observing rear mounted or pulled machinery. There was no evidence which indicated that wide-front-wheel tractors were safer under such conditions. Any inherent advantage in stability offered by the wide-front-wheel tractor seemed to be offset by the tendency of operators to take additional advantage of this stability under adverse conditions.

Speed of tractor operation must always be kept within the limits of the operating conditions. There seemed to be a tendency to operate an unloaded tractor (or tractor pulling only a wagon or trailer) at high speed, despite the surface conditions. This was indicated by the large number of accidents which occurred on the highway (non-collision) and in the farm lane. Youngsters (age 15 and under) were frequently involved in these accidents as operators as victims thrown from the tractor.

Despite concentrated educational emphasis, a number of accidents occurred which involved backwards upsets caused by improper hitching. This type of accident is nearly always fatal because of the rapidity with which the upsets occur, and the difficulty of jumping clear.

Safety workers have stressed the danger of permitting children on tractors. Despite this warning, over thirteen per cent of all fatalities were children fifteen or under who were riding on the tractor. In most of these cases the only reason for the child being on the tractor was to "joy-ride." Nearly one-fourth of all accidents involved children fifteen or under as operators, victims, or both.
LIMITATIONS

A general description of this study might be "a survey of the fatal farm tractor accident situation in Ohio from 1956 through 1960." This statement, besides describing the study, implies limitations as well.

For any survey to be of value, it must be based on a representative sample from which accurate and complete information may be gathered. Regarding the accident survey, since every accident reported was included, there is little doubt that the sample was representative within its defined limits. However, any attempts at projecting the findings beyond these limits, to include other states, non-fatal accidents, or years in the past or future should be made with considerable caution. There were no eye-witnesses to some of the accidents, and in many other accidents details remained unclear or incomplete. Thus, many determinations of factors involved and the relative importance of these factors were by necessity dependent upon a reasonable judgment of the facts available.

A portion of the accident survey accuracy was dependent upon the accuracy of the tractor population survey. Despite the method of sampling used and the size of sample, errors may have existed.
Questions on the form pertaining to hours of annual use, amount of weight added, cropland topography, and frequency of hazardous operation required estimation or arbitrary judgment by the farmer, and thus are open to question.

In many situations a survey technique is far superior to all others for identifying and classifying a problem or situation. In general, the survey does not in itself provide answers for the problem or reasons for the situation. However, by clarifying the problem, the survey can provide the proper direction for activities leading directly to the solution, and in this sense become a useful part of the problem solving process. The findings of this survey are the basis for the following recommendations for additional work in the area of farm tractor safety.
RECOMMENDATIONS

1. Means should be developed for revising tractor arrangement to permit the operator to ride behind the implement.

2. Possibilities for the general application of either roll bars with seat belts or crushproof, enclosed cabs should be evaluated. Tests of these methods of preventing injury should be conducted.

3. Safety educators should stress the dangers in operating tractors near ditches, on steep slopes, at high speed, on busy highways, towing implements using an improper hitch, and of permitting children to ride on the tractor.

4. Additional data on both fatal and non-fatal tractor accidents should be gathered in Ohio and other states.

5. The effect of varying power and weight distribution should be checked analytically and experimentally.

6. The lateral tipping equations derived in this study should be checked experimentally.

7. Possibilities of an automatic control or warning device to prevent the tractor from reaching a point of instability should be investigated.
SUMMARY

Since 1956 the number of fatal farm tractor accidents in the United States has doubled. While considerable educational effort has been directed toward the reduction of these fatalities, possibilities also exist for design changes which would make tractors safer. A logical basis for planning such engineering and educational efforts is a knowledge of the nature and extent of farm tractor accidents.

Data on 818 fatal farm tractor accidents in Ohio were gathered from 1956 through 1960. These accidents were analyzed to provide some of the necessary knowledge for sound engineering and educational planning toward reducing accident numbers. A survey conducted in 1960 provided information about the whole Ohio tractor population for comparisons with the accident data.

Upsets comprised nearly sixty per cent of the accidents. Two-thirds of these were sideways upsets. Major circumstances causing the upsets were driving into a ditch, driving on excessive slope, operating at excessive speeds, and improper pulling, in that order. Other major accident groups were accidents in which the victim fell or was thrown from the tractor, and highway collisions. Certain relationships were established between parameters such as age of
victim, place of accident, and some tractor design characteristics for specific accident types.

Recommendations encouraged the development of means which would permit the tractor operator to ride behind the implement and a suitable crushproof cab or roll bar with seat belt. They also emphasized the danger of permitting children on tractors, as well as the dangers inherent in the common accident types. Similar studies should be conducted in other states. Non-fatal tractor accidents should also be made a part of any study.
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Mitchell, Glen H., "Telephone Interviewing," Department of Agricultural Economics and Rural Sociology Department Mimeograph Series No. A.E. 279, Ohio Agricultural Experiment Station, Wooster, Ohio, 1957.


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<tbody>
<tr>
<td>Hours of Annual Use</td>
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<td>Frequency of Hazardous Op'n.</td>
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<tr>
<td>Cropland Topography</td>
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<tr>
<td>Front Wheel Arrangement</td>
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<tr>
<td>Weight to HP Ratio</td>
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<tr>
<td>Front End Wt. to HP Ratio</td>
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<tr>
<td>Drawbar Horsepower</td>
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<td>Area of the State</td>
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I - Independent
* - Dependence tested at 5% level
** - Dependence tested at 1% level
A - Strong dependence apparent
S - Strong dependence apparent from summations
(s) - Some difference in summations
TABLE IX—Continued

Notes on significant tests:

a Higher drawbar horsepower—more hours of annual use.

b Southeastern Ohio—higher frequency of hazardous operation.

c Rolling and hilly topography—higher frequency of hazardous operation.

d More rolling and hilly topography in southeastern Ohio; more level ground in northwestern Ohio.

e Lower drawbar horsepower—more used on rolling or hilly ground.

f Wide front wheels—more used on rolling or hilly ground.

g More tricycle tractors in northwestern Ohio; more wide-front-wheel tractors in southeastern Ohio.

h Lower drawbar horsepower—more wide-front-wheel tractors.

i Intermediate front end weight-to-horsepower ratio—more wide-front-wheel tractors.

j Lower weight-to-horsepower ratio—more wide-front-wheel tractors.

k Higher weight-to-horsepower ratios in northwestern Ohio; lower ratios in southeastern Ohio.

l Lower drawbar horsepower—higher front end weight-to-horsepower ratios.

m More low horsepower tractors in southeastern Ohio.
Shaded bars - age distribution of accident victims
Unshaded bars - age distribution (approximate) of Ohio farm Operators

Fig. 2.--Ages of Accident Victims
1. By years

2. By months

3. By time of day

Note: Numbers on graphs indicate total number of accidents in categories.

Fig. 3.—Accident Time Variations
Fig. 4.—Position of Victim Relative to Tractor

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<tr>
<th>Type of Implement</th>
<th>Per cent of all accidents</th>
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<tbody>
<tr>
<td>None</td>
<td>34.8</td>
</tr>
<tr>
<td>Wagon or trailer</td>
<td>16.7</td>
</tr>
<tr>
<td>Cutting implements</td>
<td>8.6</td>
</tr>
<tr>
<td>Tillage tools</td>
<td>7.1</td>
</tr>
<tr>
<td>Plow</td>
<td>6.7</td>
</tr>
<tr>
<td>Manure loader</td>
<td>6.7</td>
</tr>
<tr>
<td>All others</td>
<td>20.1</td>
</tr>
</tbody>
</table>

Fig. 5.—Equipment Operated with Tractor
Shaded bars—accidents
Unshaded bars—population

ALL ACCIDENTS
(1% level significance)

Per cent
40

20

0

under 120
120

140
140

160
160

180
180

over

Pounds per Horsepower

BACKWARDS UPSETS
(5% level significance)

Per cent
40

20

0

under 120
120

140
140

160
160

180
180

over

Pounds per Horsepower

Fig. 6.—Accident vs. Population
Distribution by Pounds per Horsepower
Shaded bars—accidents
Unshaded bars—population

Per cent
40
20
0
under 35 35-40 40-45 45-50 50+
Front End Pounds per Horsepower

ALL ACCIDENTS
(no significant difference)

Per cent
40
20
0
under 40 40-45 45+
Front End Lb. per HP

THROWN OR FALLEN TYPE
(5% level significance)

Fig. 7.—Accident vs. Population
Distribution by Front End Pounds per Horsepower
Fig. 8.—Accident vs. Population Distribution by Drawbar Horsepower
Fig. 9.—Accident vs. Population Distribution by Tractor Front Wheel Arrangement
Tractor Fatality Study
Conducted by
Agricultural Extension Service
and
Ohio Farm & Home Safety Committee

Name of deceased ___________________________ County ________

Address _______________________________________

Age _______ Date of accident _________ Description of accident __________________________

Data collected by _______________________________ Date __________

A. Was the deceased a member of a family which was:
   1. Full time farming __________ 2. Part time farming __________
   3. Works full time in occupation other than farming ________________

B. Was deceased driving the tractor at the time of the accident?
   Yes ______ No __________

C. If deceased was driving, how many years had he been driving a tractor?
   _______ Years

   For how many years or months had he driven this tractor? __________

   If deceased was not driving, how many years had the driver been
driving a tractor? _______ Years ______ Age of driver _______ Sex _________

D. What time of day did the accident occur? _______ A.M. ___ P.M. ____

E. Where did the accident occur:
   In the field ___________ On the highway _______________________
   In the farmyard ______ On the farm lane _________________________
   In a building __________ Elsewhere (explain) ____________________

F. What was the weather condition: raining at the time _____, dry _____
   surface slippery (snow or ice) _____, other ______________________

G. Was there mechanical failure? ______________ Yes __________ No.

I. What equipment was being pulled or operated by tractor? ___________

J. What type of tractor was involved in accident? Tricycle ______,
   4-wheel _______, Crawler ________, Other ______________________
K. Make of tractor __________________ Model ______________________

L. Did tractor overturn? Yes _____ No _____ If yes, was it:
   Backwards _________ Sidewise _________ Forward _________

M. If tractor overturned, check the following conditions which apply:
   1. Traveling on the level _____ 8. Tractor stuck in mud _____
   2. Going up hill _____ 9. Pulling out a mired tractor, truck or implement _____
   3. Going down hill _____ 10. Hitched to tractor anyplace other than the drawbar _____
   4. Crossing slope (on contour) _____ 11. Driving too fast _____
   5. Wheel hit a hidden object _____ 12. Tractor was being pulled at high speed by truck _____
   6. Wheel dropped in hole or ditch _____ 13. Other causes not listed (explain) ____________________________
   7. Turning at fast speed _____

N. Did tractor have:
   Rear wheel weights _______ Tires filled with liquid ______
   Front wheel weights _______
   Rear wheels spaced in narrow ____ intermediate ____ wide ____ position.

O. If the tractor did not overturn, how did the accident occur? ____________________________
   ____________________________
   ____________________________

P. In your own words, how could this accident have been avoided?
   ____________________________
   ____________________________
   ____________________________
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<tr>
<td></td>
<td>1. Crushed</td>
<td>1. Human</td>
<td>1. Fatigue</td>
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<tr>
<td></td>
<td>3. Run over-mach.</td>
<td>3. Envir.</td>
<td>3. Ignorance</td>
</tr>
<tr>
<td></td>
<td>4. Caught in mach.</td>
<td>4. H + M</td>
<td>3. Ignorance or lack of judgment</td>
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<tr>
<td></td>
<td>5. Fall</td>
<td>5. H + E</td>
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<tr>
<td></td>
<td>6. Auto, etc.</td>
<td>6. E + M</td>
<td>4. Inattention</td>
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<td></td>
<td>7. PTO, etc.</td>
<td>7. All</td>
<td>5. Physical malfunction</td>
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<tr>
<td></td>
<td>8. Other</td>
<td>8. Unknown</td>
<td>6. Hurry</td>
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<thead>
<tr>
<th>E. (8) Machine</th>
<th>F. (9) Environment</th>
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<tr>
<td>2. Unus. instability</td>
<td>2. Ditches, etc.</td>
</tr>
<tr>
<td>3. Bad hitch</td>
<td>3. Holes, etc.</td>
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<tr>
<td>4. Fenders, etc.</td>
<td>4. Slippery</td>
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<tr>
<td>5. Trailing mach.</td>
<td>5. Incl. weather</td>
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<tr>
<td>7. Front lighting</td>
<td>7. Slope</td>
</tr>
<tr>
<td>8. Rear lighting</td>
<td>8. Other</td>
</tr>
<tr>
<td>9. PTO</td>
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<td>10. Poor vision</td>
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<th>H. (11) Victim was</th>
<th>I. (12-13) Tractor Make Model</th>
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<tbody>
<tr>
<td>1. Driving tractor</td>
<td>1. Case</td>
</tr>
<tr>
<td>2. Riding tractor</td>
<td>2. AC</td>
</tr>
<tr>
<td>3. Riding mach.</td>
<td>3. Ford</td>
</tr>
<tr>
<td>4. Off both</td>
<td>4. IH</td>
</tr>
<tr>
<td>5. Unknown</td>
<td>5. JD</td>
</tr>
<tr>
<td>6. Ferguson</td>
<td>6. Ferguson</td>
</tr>
<tr>
<td>7. Massey</td>
<td>7. Massey</td>
</tr>
<tr>
<td>8. MM</td>
<td>8. MM</td>
</tr>
<tr>
<td>9. Oliver</td>
<td>9. Oliver</td>
</tr>
<tr>
<td>10. S King</td>
<td>10. S King</td>
</tr>
<tr>
<td>12. Other</td>
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<th>M. (19) Upset</th>
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<tr>
<td>1. 6-9 AM</td>
<td>0. Did not upset</td>
</tr>
<tr>
<td>2. 9-12 AM</td>
<td>0. Backwards</td>
</tr>
<tr>
<td>3. 12-3 PM</td>
<td>1. Too fast</td>
</tr>
<tr>
<td>4. 3-6 PM</td>
<td>2. Up hill</td>
</tr>
<tr>
<td>5. 6 PM-6 AM</td>
<td>3. Down hill</td>
</tr>
<tr>
<td>6. AM</td>
<td>4. Cross slope</td>
</tr>
<tr>
<td>7. PM</td>
<td>5. Bump or hole</td>
</tr>
<tr>
<td>8. Unknown</td>
<td>6. Hitch other than DB</td>
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<thead>
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<th>M. (18) Place</th>
<th>N. (20) Factors</th>
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<tr>
<td>1. Field</td>
<td>1. Too fast</td>
</tr>
<tr>
<td>2. Farmyard</td>
<td>2. Mounted</td>
</tr>
<tr>
<td>3. Building</td>
<td>2. Pulled</td>
</tr>
<tr>
<td>4. Highway</td>
<td>Type</td>
</tr>
<tr>
<td>5. Farm lane</td>
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<td>6. Other</td>
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<tr>
<td>0. None</td>
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<tr>
<td>1. Mounted</td>
</tr>
<tr>
<td>2. Pulled</td>
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<th>Q. (22) Weather</th>
<th>R. (23) Occupation</th>
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<tr>
<td>0. Not a factor</td>
<td>1. None</td>
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<td>1. Cold</td>
<td>2. Mounted</td>
</tr>
<tr>
<td>2. Heat</td>
<td>2. Pulled</td>
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<tr>
<td>3. Rain</td>
<td>3. Mounted</td>
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<td>4. Snow</td>
<td>4. Pulled</td>
</tr>
<tr>
<td>5. Other</td>
<td>5. Pulled</td>
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| #5. Number of tractors on farm | "Fig. 12.—Telephone survey form"

| 22. | County |
| 23. | Acres of cropland |
| 24. | Full-time farming |
| 25. | Part-time farming |

| 30. | Used on |
| 31. | Tractor make |
| 32. | Model |
| 33. | Year made |
| 34. | Hours used |
| 35. | Horsepower (PS) |
| 36. | Front wheel size |
| 37. | Front wheel width |
| 38. | Rear wheel size |
| 39. | Rear wheel width |
| 40. | Other information |
| 41. | Normal PS |
| 42. | Horsepower (HP) |
| 43. | Normal HP |

Fig. 12.—Telephone survey form
Tractor Tragedy

will you be a victim

Agricultural Extension Service
The Ohio State University

Revised April, 1958

Fig. 14.—Tractor safety pamphlet
Tractor Tragedy
By Wilbur Stookey and William Oill
"Mother of four is killed by tractor"
"Fowler man, pinned by tractor, dies"
"Boy is killed in drop from tractor"
"Tractor crash kills farmer"

These newspaper headlines were typical of 47 such stories that appeared in Ohio newspapers in 1957. When such a story appears, many of us read the headlines then turn to the sports page or comics with a passing thought of "that's too bad."

Let's stop for a minute to give this situation due consideration. Forty-seven persons in Ohio were killed and hundreds of others crippled for life, because they misused the farm tractor. A machine designed and manufactured to increase production, lighten our work and make life more pleasant has, in these cases, resulted in destruction of human life.

A further study of the 47 fatalities reveals some startling facts.

How did these accidents occur?
Fifty-seven percent of the deaths occurred when the driver was pinned beneath the overturned tractor. The others occurred when the victim had a crash on the highway, was caught in the power-take-off shaft, was run over by or thrown from tractor and similar circumstances.

Who was killed in these accidents?
Fifty-nine percent of the victims were full-time farmers. Thirteen percent were employed full time off the farm.

What Common Practices Result in Accidents?
How Can They Be Prevented?

Stuck in Hole
Something will turn if power is applied. If wheels stick, chains will revolve around once. When you can't back out, get help.

Travelling on Highway
High-speed traffic and slow-speed tractors don't mix—safety. Use lights at night and red flag during the day. Pull off highway to let backing of traffic go by.

Hitch Too High
Never link to side, hydraulic lift when raised or any part of tractor except drawbar. Always pull load by hitching to drawbar at recommended heights, usually between 13 and 17 inches from ground.

Crossing a Slope
A hole, bump or quick turn may result in an upset on a slope. Be extra careful on a slope. Don't farm if it is too steep.

Loads on Drawbar
Loads on drawbar increase chances of a backward upset going up hill. Add front end weights, drive tractor slowly and carefully on slopes.

Ditches
This tractor may tip backwards when power is applied. Sideways upsetting often happens in ditches. Avoid steep banks. Cross ditches where banks have gradual slopes. Slow down when turning at end of fields.

Hit Hidden Object or Hole
A hidden stone, log or hole can throw drier and upset tractor. Slow down when vision is obscured or on rough land.

Horseplay
Heavy loads on front end loader make big-scale tractor upset easily on rough, uneven or sloping ground. Add rear wheel weights and use loader with caution.

Tractor Hitchhiker
Several hitchhikers are thrown from tractors and killed each year in Ohio. The tractor is designed for one rider—no one else.

Unshielded P.T.O.
Some deaths result from using tractor to run cranks, belt-castor or from just plain horseplay. Use tractor for jobs for which it was designed.

Towing Tractor Too Fast
Towing tractor at high speed with track has resulted in loss of control of tractor due to broken rope. Either haul tractor in truck or pull it at slow tractor operating speeds.

Trousers legs coming in contact with revolving, exposed P.T.O. shafts result in severe injury or death. Never operate P.T.O. without safety shields in place.

How old were the victims?
Thirty-six percent were between the ages of 25 and 65 years. Those under 15 years accounted for 30 percent of the deaths.

At what time of day did the accidents occur?
Twenty-eight percent occurred between 9 am and noon, while 54 percent occurred between noon and 6 pm.

Where did they occur?
About one-fifth occurred on the highway, but 3 times this number occurred in the field and farm lane.

Were both men and women involved in these accidents?
Yes, however, 44 of the 47 victims were men and boys.

Why did these accidents occur?
Mechanical failure was listed as a cause in only 1 of the cases. So, the answer is human failure.

What did the drivers do to cause the tractors to overturn?
Twelve of the 27 drivers, who died when their tractors overturned, were operating on level ground. Six were going up hill, 5 downhill and 4 on the contour. The wrong hitch was a factor in 1 case, while a wheel striking a hidden object or dropping into a hole or ditch was a factor in another 10 overturns.

What types of tractors were involved in these overturns?
Surprising as it may seem, 43 percent were 4-wheelers.
Could the family stand the financial loss? Today, doctors, specialists, medicines, and other such items come high. A few weeks in the hospital can wipe out a $5,000 savings account in a hurry. If a breadwinner happens to be the victim, how will the family manage to get by?

How would the family stand the shock? Whether it be Mother, Dad, or little Jane who dies, the family would not be the same. No one could take the place of a number of your family. Regardless of how hard you try, it can’t be done.

YOU CAN’T HARVEST A CROP IN THE HOSPITAL

Suppose you were one of the hundreds who had a serious accident during the past year. How would you answer these questions?