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A Review of Farm Accident Data Sources and Research: Review of Recently Published and Current Research[1]

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Research on farm accidents centers around causes and severity of injuries and illnesses, health and safety of youth, farm safety education, and improved survey techniques. Examples of research from each of these areas are discussed below.

INJURIES AND ILLNESSES

Gerberich and others point out the need for continued and improved injury surveillance. "A major barrier to progress in the prevention of agricultural injuries has been not only a lack of knowledge about the magnitude of the problem but also a deficiency in knowledge about the specific causes or risk factors due to the lack of analytical studies" (Gerberich and others, 1991, p. 161). The status of injuries and illnesses on farms is one of the first items of information that should be determined. Status of injury or illness includes information about the victim, the agent that caused the injury or illness, the task being performed when the illness or injury occurred, and other information that will describe the event.

Injuries

Injuries in farming range from cuts and scrapes to total disabilities and fatalities. Most traumatic injuries occur during interactions with machinery, especially tractors (Bean, 1991). Injuries also result from poor building design, electric power, livestock handling, and weather conditions. The activities that victims were most often performing when injured are machinery maintenance, fieldwork, and caring for animals (Hoskin and others, 1988b and 1988c; Pollock, 1990; and Yoder and others, 1989).

Tractors. Tractor accidents have been identified as the leading cause of deaths and disabling injuries on farms (National Coalition for Agricultural Safety and Health, 1988). Tractors are the most frequent cause (one-third to one-half) of injury for fatal farm accidents but account for a much smaller percentage (5 to 10 percent) of nonfatal farm accidents, according to Murphy (Murphy, 1990). Murphy also reports that the types of fatal tractor accidents have not changed over the last 20-plus years, with overturn accounting for about one-half and runover accounting for about one-fourth of such accidents (Murphy, 1990). The results from a study of tractor fatalities in New York between 1985 and 1988 by Pollock support Murphy's findings (Pollock, 1990). Most deaths caused by overturns and runovers could be prevented if tractors were equipped with rollover protective structures (ROPS) and seat belts and if passengers were not allowed on tractors. However, only about one-third of the tractors on U.S. farms are equipped with such protective structures (Heffernan, 1991). According to a study in Pennsylvania, less than 19 percent of the tractors had ROPS (Huizinga and

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Murphy, 1988). Other types of fatal injuries involving tractors are caused by power takeoff (PTO) entanglements, contact with overhead electrical wires, and road collisions (Madsen, 1991).

Not all injuries involving tractors are fatal. Hoskin and others, in their report on tractor-related injuries, showed that "struck by or against" an object and fall from a different level were the most frequent types of injuries. These generally resulted in bruises or fractures (struck by or against) and fractures or sprains to the foot (fall) (Hoskin and others, 1988b). Most of the struck by or against accidents occurred during fieldwork, but most of the accidents by falls occurred while the tractor was parked or stationary (Hoskin and others, 1988b). In another tractor safety study, Schumacher and others visually inspected tractors to determine whether tractor owners/operators were maintaining and using original equipment manufacturers (OEM) safety devices (Schumacher and others, 1989). This study drew two conclusions. First, "farm tractor owners/operators tend to neglect the maintenance of OEM tractor safety devices as the age of the tractor increases" (Schumacher and others, 1989, p. 5). Second, "in the most general way, a lack of safety consciousness on the parts of tractor owners/operators was apparent" (Schumacher and others, p. 5).

Machinery Other Than Tractors. Hoskin and others in their study of machinery-related injuries showed that most accidents occurred when the victim was struck by or struck against the machine while performing maintenance on combines with grain heads when the machine was not running (Hoskin and others, 1988a). Other types of injuries that happen when working with machinery include entanglements in belts, chains, gears, power takeoffs at the tractor and along the PTO drive, and crop gathering and moving mechanisms (Madsen, 1991). Most machinery is manufactured with protective devices, and warning signs are placed on the machines at spots where workers can become easily entangled.

Nonmachinery. Hoskin and others report the most frequent type of nonmachinery-related injuries is 'struck by or against an object. These injuries generally result in a bruise or fracture to the head and most often happen while performing chores involving animals or treating animals (Hoskin and others, 1988c). A Pennsylvania study supports these findings, showing that the largest percentage of farm injuries occurred in barns (30 percent), fields (16 percent), barnyards (14 percent), and farm buildings (12 percent) (Huizinga and Murphy, 1988).

ILLNESSES

Farmers and farmworkers have higher rates than other workers of respiratory disease, certain cancers, acute and chronic chemical toxicity, dermatitis, musculoskeletal syndromes, noise-induced hearing loss, and stress-related mental disorders (National Coalition for Agricultural Safety and Health, 1988).

Respiratory Disease. Respiratory diseases are not new to farmers and farmworkers. In 1713, Bernardino Ramazzini wrote that "measurers and sifters of grain were at risk for respiratory problems," and in 1832, Charles Thackrah "described a relationship between asthma and inhalation of corn dust" (Von Essen, 1991). In 1974, a study by a small group of veterinary practitioners showed that respiratory problems appeared in workers exposed to swine confinement areas (Donham, 1992).

According to Von Essen, at least six disorders are associated with exposure to airborne dusts in farming: hypersensitivity pneumonitis (HP), organic dust toxic syndrome (ODTS), chronic bronchitis (CB), acute pulmonary symptoms (APS), asthma, and mucous membrane irritation (MMI) (Von Essen, 1991). HP is caused by exposure to antigens found in silage and in spoiled hay and grain. HP is commonly seen on dairy farms but has also been found on farms where grain is stored in drying bins and is found in poultry houses and mushroom houses (Von Essen, 1991). ODTS occurs after exposure to large amounts of organic dust (Von Essen, 1991). Workers affected by ODTS include those uncapping silos on dairy farms, cleaning grain bins, moving moldy grain, and working in swine confinement facilities (Von Essen, 1991). The precise cause of CB, other than airborne dust, has not been isolated; nor have the individuals who are at high risk been identified. However, workers in swine confinement areas, poultry farmers, and handlers of grain appear to have risks of suffering from CB (Von Essen, 1991). The occurrence of APS has been studied in grain farmers and swine confinement workers, and both groups have exhibited symptoms (Von Essen, 1991). Asthma can be triggered by many farm antigens. Also, many farm antigens cause MMI.

In addition to airborne dusts, some gases can cause acute toxicity. The primary locations of these gases are silos, manure pits, and modern semienclosed animal production buildings (Hurst, 1992; Popendorf, 1991; and Zwemer and others, 1992). Soon after corn is ensiled, nitrogen oxide levels begin increasing and continue to increase for about 7 days. Anyone entering silos during the first 2 weeks after filling may experience difficult or labored breathing (dyspnea) or, in the extreme case, death (Popendorf, 1991; and Zwemer and others, 1992). Hydrogen sulphide, methane, ammonia, carbon dioxide, and carbon monoxide are some of the toxic gases emanating from manure pits, especially when the manure is being agitated (Hurst, 1992). Even when the levels of these gases are not high enough to be fatal, unconsciousness may cause drowning or near drowning in manure liquids (Hurst, 1992). High levels of ammonia have been documented in poultry and swine confinement facilities, especially in winter (Popendorf, 1991). Concentrations of ammonia in these facilities would ordinarily be only a strong irritant to the eyes, nose, and throat but when combined with organic dusts could cause pulmonary damage (Popendorf, 1991).

Cancers. Leukemia, Hodgkin's disease, non-Hodgkin's lymphoma, multiple myeloma, and cancers of the lip, skin, stomach, prostate, and brain have excessive occurrences in farmers (Novello, 1991). The marked frequency of these cancers in farmers have not been conclusively identified (Blair and Zahm, 1992; McDuffie and others, 1988; McDuffie and others, 1990; and Novello, 1991). However, "cancers of the skin and lip are linked to increased exposure to the sun's ultraviolet radiation," and exposures to nitrates, pesticides, viruses, antigenic stimulants, and various fuels, oils, and solvents are suspected causes of many cancers (Novello, 1991; and U.S. Department of Heath and Human Services, 1991a). Some evidence indicates women on farms have higher incident rates of multiple myeloma than do farm men (Zahm and others, 1992a).

Pesticide Toxicity. Exposure to pesticides can produce acute and chronic toxic reactions. Acute reactions develop immediately after moderate or high exposures to pesticides. Symptoms of acute reactions include dizziness, vomiting, headache, fatigue, drowsiness, and skin rashes. Although this area of toxicity is not yet fully scientifically documented, some of the suspected chronic effects are central nervous system damage, lung diseases, soft tissue sarcoma, Hodgkin's disease, non-Hodgkin's lymphoma, leukemia, and lung cancer (Blair, 1991; National Coalition for Agricultural Safety and Health, 1988, and Zahm and others, 1992b). More research on the chronic effects of pesticide exposures is required.

Dermatitis. Occupational dermatitis is very common among workers on U.S. farms (National Coalition for Agricultural Safety and Health, 1988). Among the agents causing dermatitis and related skin conditions are ammonia fertilizers, animal feed additives, pesticides, plants, sunlight, cattle, swine, sheep, moist and hot environments, and chiggers, bees, and wasps (Blair, 1991; Susitaival and others, 1992; Zwemer and others, 1992).

Musculoskeletal Syndromes. Degenerative musculoskeletal syndromes are widespread among farmers and farmworkers (National Coalition for Agricultural Safety and Health, 1988; and Novello, 1991). Low back pain, hip arthrosis, and degenerative arthritis of the knee and upper extremities are the syndromes most often reported (National Coalition for Agricultural Safety and Health, 1988; and Novello, 1991). Chronic vibration from tractors and farm machinery and repetitive trauma associated with farm work can lead to musculoskeletal syndromes (Barbieri and others, 1992; Holness and Nethercott, 1992; National Coalition for Agricultural Safety and Health, 1988; and Novello, 1991).

Noise-induced Hearing Loss. Another occupational hazard for farmers and farmworkers is hearing loss caused by exposure to farm machinery, especially tractors. Hearing losses affect about a quarter of younger farmers and one-half of older farmers (May and Dennis, 1992; National Coalition for Agricultural Safety and Health, 1988; Novello, 1991; and Reesal and others, 1992). "Significant numbers of those affected have been found to develop a communication handicap by age 30" (National Coalition for Agricultural Safety and Health, 1988, p. 21).

Stress-Related Mental Disorders. Farmers, farmworkers, and farm family members have high rates of stress-related mental disorders, especially depression (Heffernan, 1991). "Some of these disorders appear to be related to isolation, and others result from agricultural stressors such as economic hardship and weather conditions" (National Coalition for Agricultural Safety and Health, 1988, p. 21). Factors beyond a farmer's control, such as reduced revenue, increased workload, weather, and management problems, were found to cause significant mental stress (Crevier and Brun, 1992).

HEALTH AND SAFETY OF YOUTH

Youth present a special problem in the area of farm safety. The Fair Labor Standards Act limits the employment of minors according to age and occupational activity (Runyan, 1992).[1] Some children as young as 10 years old may work on farms with parental consent. Children of farm operators may work for their parents on their own farms at any age. In addition, many children are at risk by living on farms. A study of 169 Iowa farm families highlights some of the safety issues related to youth:

1. more than 40 percent of the children who operated equipment were not supervised;

2. about 30 percent of children more than 3 years old played alone in work areas and 80 percent of them played near machinery in operation; and

3. children began operating equipment at an average age of 12, even though parents believed their children were not capable of operating equipment until age 15 (Hawk and others, 1991).

An earlier study of injuries to farm youth (less than 20 years of age) in 1979, 1980, and 1981 used national statistics (Reesal and others, 1992). According to this study,

1. about 300 youth die each year from farm injuries and 23,500 suffer nonfatal injuries;

2. rates of fatal and nonfatal injuries increase with the age of the victim;

3. fatal and nonfatal injury rates are much higher for males than for females;

4. more than one-half of the victims of fatal farm injuries die before reaching a physician, nearly one-fifth die in transit to a hospital, and about one-tenth live long enough to receive in-patient care;

5. nearly 90 percent of the nonfatal injuries were treated in an emergency room and released; and

6. accidents involving farm machinery accounted for most of the fatal and nonfatal injuries, with tractors being involved in more accidents than other machinery. Other farm machinery involved in such accidents were wagons and combines. However, these findings may be somewhat misleading because the data include deaths due to drowning and firearms and do not distinguish between recreation and farm-related activities as agents of death (Rivara, 1985).

A study of fatal farm-related injuries to children 9 years of age and under in Wisconsin and Illinois from 1979 to 1985 that used death certificate data showed the average annual death rates in the study population were 3.2 per 100,000 in Wisconsin and 1.5 per 100,000 in Illinois (Saimi and others, 1989). The study found that the death rate was substantially higher for boys than for girls, that most fatalities occurred in July, and that machinery was the source of more than one-half of the injuries in Wisconsin and Illinois during the period of the study (Salmi and others, 1989).

FARM SAFETY EDUCATION

The most successful education efforts to improve farm safety will involve farmers, farm family members, farmworkers, educators (both extension and institutional), researchers, farm equipment design engineers, and political policy leaders. All of these groups have a stake in farm safety. A brief review of some literature on farm safety education follows.

Farmers' Perceptions of Heath and Safety Issues

One of the first questions to ask when planning an education program is whether or not the participants realize a problem exists. Research studies in New York and in Iowa focused on farmers' perceptions of health and safety issues, accident causes, and methods of accident prevention (Kendall and others, 1990; and Pollock, 1990). Both studies showed farm families to be aware that farming is a hazardous occupation and that safety is important even when this factor is ranked alongside such matters as prices and the environment. Findings also indicated that farm families were receptive to receiving constant reminders and literature about safe working practices, especially when these practices could be put to use by all ages. Farm magazines, the Cooperative Extension Service, and local equipment dealers (in the Iowa study) were found to be the most frequently used sources of safety information. Farm families participating in the New York study had reservations that safety meetings might not be the best way to communicate safety information (Pollock, 1990).

Farm operators and family members are aware of farming hazards, but in times of stress, such people may make decisions that under more ideal conditions would have been considered dangerous and unwise. For example, a farmer may throw aside a bent power takeoff shield so that grain unloading can go forward, rather than wait until the shield can be repaired. In this example, the operator is unconsciously making the economic decision that the value of the time required to repair the shield is greater than the potential loss that might result from an injury. But, under identical conditions, this same operator would probably not forget to check the tractor's oil level or to lubricate the moving parts as required.

Suggested Methods for Educating About Farm Safety

Individuals concerned with occupational and farm safety issues frequently ask, "If nonagricultural industries can reduce their death and injury rates, why can't agriculture?" Aherin and others suggest that the answer to this question lies in the lack of engineering research and research funding for agricultural safety. However, these authors argue that "it is equally important to recognize that we should not stop trying to do a better job with education methods" (Aherin and others, 1990, p. 19). The authors suggest that behavioral psychology may help in providing solutions for this continuing problem (Aherin, 1991; and Aherin and others, 1990).

Variables of Effective Safety Communication. Aherin and others identify several variables of effective safety communication: source characteristics, social support/conformity, personal involvement, and characteristics of the message itself. They argue that the most effective message will be conveyed by one who is an expert in agricultural issues, is trusted and liked by farmers, and is as similar as possible to farmers (source characteristics). Furthermore, they suggest that people comply more often with persuasive arguments when with others who have complied also and that attitudes change more when the message presented is extremely different from the one already believed by the receiver (social support/conformity). Also, "any program that requires the direct participation of the farmers could potentially increase persuasion and safety behavior" (personal involvement) (Aherin and others, 1990, p. 16).

Elements for Safety Communications. Aherin and his colleagues also note the importance of the characteristics of the message. They identify four elements that should be included in any safety communication:

1. "the nature of the hazard;
2. the level of seriousness of the hazard;
3. how to practically avoid the hazard; and the potential consequences of not avoiding the hazard" (Aherin and others, 1990, p. 16).

These authors use warning signs and labels, a major form of safety communication by machinery manufacturers, to demonstrate these four elements. To be effective, labeling of hazardous machinery parts requires that

1. the users must perceive that a dangerous situation exists,
2. the explanation of the consequences of disregarding the warning must be memorable to the hearers,
3. the cost of complying with the warning in terms of time or inconvenience should not exceed the users' willingness to comply, and
4. the example of those who profit by the warning can inspire others to do the same. In brief, the warning text that accompanies the label must be explicit and must answer the question, "Why should I obey?" (Aherin and others, 1990, p. 18).

An Example of a Safety Education Effort

One example of an effort to educate people about farm safety is a farm safety audit called "Farm Safety Walkabout," which could be used either as an individual or as a community activity, and which was developed at the University of Iowa (Hawk and others, 1992). The audit has six one-page sections: people, house, farmyard, farm and livestock buildings, machinery, and evaluation (of the audit). The handbook provides all the materials necessary to carry out a community activity as well as the safety audit, a farm family health and safety community survey, a pretest to gather information on safety practices, a post-test to evaluate the effect of the program, a resource list, an accident emergency information sheet, and a basic list of supplies for a well--equipped emergency first-aid kit for a rural home. Gogerty's report gives an evaluation of the usefulness of this audit (Gogerty, 1991).

SURVEY METHODS

Much of the research published during the past few years concerning farm safety has either focused on survey methods or devoted a section to survey methods. Two survey methods are used most frequently to collect farm accident data: surveys of farm households and surveys of death certificates.

Farm Household Surveys

The following discussion includes a survey that was methodologically sound but had implementation problems and a survey that is being tested.

Standard Farm Accident Survey Program. In the late 1960's, extension safety leaders at Ohio State and Michigan State Universities developed a standardized method of collecting agricultural accident data (Baker and others, 1990). Using the Ohio State-Michigan State research as a basis, the National Safety Council, in cooperation with the U.S. Department of Agriculture, developed and implemented the Standard Farm Accident Survey Program (Baker and others, 1990). Although the Standard Farm Accident Survey Program was methodologically sound, consistent implementation from State to State was difficult because the survey relied heavily on volunteers to collect the data and because selecting and maintaining a stratified sample proved to be difficult (Baker and others, 1990). Also, some States did not participate in the study, which limited its usefulness as a national data source. For these and other reasons, this survey was not conducted after 1984 (Murphy and Huizinga, 1989).

Modified Total Design Method. In 1988, a new method for collecting farm accident data was tested in Pennsylvania through a cooperative effort involving Pennsylvania State University, the National Safety Council's Agriculture Division, and the National Institute for Occupational Safety and Health. This new survey used a modified Total Design Method (TDM) of a personalized mail survey (Baker and others, 1990; Murphy and Huizinga, 1989; and Pollock, 1990)."[2] The survey was based on a random stratified sample from the most up-to-date mailing list of farm operators in the State; stratification variables were type, size, and geographic location of the farm. Although mail surveys frequently have low response rates of 25-30 percent, the Pennsylvania survey had a response rate of 76 percent (Baker and others, 1990; Huizinga and Murphy, 1988; and Murphy and Huizinga, 1989).

During 1989, four more States (Illinois, Missouri, Oregon, and West Virginia) joined the cooperative effort to test the TDM survey technique (Pollock, 1990). Researchers in four other States (Delaware, Indiana, New York, and Ohio) independently used the TDM survey technique. The States conducting the survey in 1989 and the respective response rates were Illinois (85 percent), Missouri (57 percent), New York (56 percent), Oregon (82 percent), West Virginia (57 percent) (Baker and others, 1990; and Pollock, 1990).[3] Based on the surveys in 1988 and 1989, the survey was economical, averaging about $7.50 per response (Baker and others, 1990). The goal now is to pool the data from the various States and to evaluate TDM as a national data collection technique.

Baker and others indicate two shortcomings of the survey: it does not allow for in-depth analysis of all accidents, and ft does not discover many fatal accidents (Baker and others, 1990). Two changes that may help are Dillman's adaptation of the TDM for telephone surveys, which would gather more detailed national accident data, and the improvements suggested by Murphy, which rely on death certificate data (Murphy, 1989). The telephone survey will allow for in-depth analysis but will increase the cost of the survey. Suggested improvements to make death certificates a more accurate and useful method for obtaining farm fatality data (as discussed below) will require some institutional changes that may come about slowly.

Surveys of Death Certificates

In a paper presented in 1989, Murphy made the point that "quantifying agricultural occupational fatalities is anything but an exact science," (Murphy, 1989, p. 1). The death certificate, the primary resource used for documenting these fatalities, contains inaccurate and incomplete occupation and industry information (Gerberich and others, 1991; and Murphy, 1989). To help improve occupation and industry data, Murphy suggests that officials use *The Standard Industrial Classification Manual* (SIC code) and the guidelines provided by the National Center for Heath Statistics to help complete the industry and occupation spaces on death certificates (Murphy, 1989). In addition to these resources, he also suggests obtaining relevant information from a family member of the victim (Murphy, 1989). This information, once properly collected, can be presented by industry sector group as well as by industry total and also compared with fatality data from other major industries (Murphy, 1989).

Other Suggestions To Improve Surveys

As the following discussion indicates, more than survey methodology is required to accurately capture farm accident data.

Classifying Farm Accidents. Farm safety research has been inconsistent in identifying accidents that are workrelated as distinct from those that are not. Purschwitz and Field discuss the need for consistency in the definition of a farm accident and present in a report of 1989 a set of decision rules for classifying farm accidents as work-related, recreational, home-related, or other (Purschwitz and Field, 1989).

Standardized Categories. Research on tractor accidents highlights problems of classifying data (Murphy, 1990). Murphy notes that most of the tractor accident data collected over the past 20 years have not "progressed beyond simple descriptors, (Murphy, 1990, p. 3)."[4] These descriptors give few clues as to how to hasten reduction of tractor accidents. Murphy argues for standardized categories for analysis and consistent presentation of general descriptive data (for example, are farm children persons under 20 years of age, 14 years and under, or some other age?) and exposure data (hours of tractor use) (Murphy, 1990). He expands this line of thinking to include many aspects of farm safety in a subsequent paper (Murphy, 1991).

Research in Progress

Studies of farm accidents are being conducted using the new survey techniques mentioned earlier in this report. Two of these are discussed below. In addition, papers presented at the Third International Symposium: Issues in Heath, Safety and Agriculture and the Surgeon General's Conference on Agricultural Safety and Heath discuss research in progress on a broad range of topics (Centre for Agricultural Medicine, 1992; and U.S. Department of Health and Human Services, 1991 b).

Eight-State Study. A NIOSH-sponsored study by John Myers analyzed data on farm injuries in Delaware, Illinois, Indiana, Missouri, New York, Ohio, Oregon, and West Virginia. A paper summarizing the farm injuries in these States has been submitted to the *American Journal of Public Health.* The paper includes injury incident rates and a discussion of the data-gathering technique. A second paper is being prepared from the tractor exposure data gathered during the study.

University of Minnesota Study. In 1991, a study of farm accidents in Minnesota, Nebraska, North Dakota, South Dakota, and Wisconsin was conducted by the University of Minnesota under a grant from the Centers for Disease Control (Gerberich and others, 1991). Data for this study were obtained through two telephone interviews per sample unit. The interviews were 6 months apart, and each resulted in about 4,000 completed interviews. Results of this study are not yet available.

1. See appendix for summary of the minimum age requirements of the Fair Labor Standards Act.

2. Total Design Method, developed by Don A. Diliman (Dillman, 1978), consists of two parts. First, the researcher must identify each aspect of the survey that may affect quantity and quality of the survey. This includes personalizing all aspects of the survey such as cover letters, survey instruments, and envelopes. Second, the survey should be organized so that design intentions are carried out in complete detail. There should be no monetary cost to the respondent, the survey instrument must be attractively designed, and the relevance of questions should be obvious to the participants (Baker and others, 1990, p. 4).

3. Data were not available from Delaware, Indiana, and Ohio.

4. Descriptors refer to variables such as the age and sex of the victim, the time of year of the accident, severity of the accident, and the general use of the tractor at the time of the accident.