Reducing Farm Injuries:

Issues and Methods

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ABSTRACT

Agriculture is a hazardous industry with several unique characteristics which contribute to safety and health problems. Past and current efforts at injury control are reviewed with an emphasis on agricultural and public health approaches. Theories on modifying farm worker safety behaviors and communicating safety and health information are reviewed. Several recommendations for agricultural safety and health professionals are given.

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CHAPTER I
INTRODUCTION

INJURY AS A PUBLIC HEALTH PROBLEM

In previous decades, infectious diseases caused the majority of American deaths. Controlled by vast improvements in medical technology and public health promotion, disease is no longer the greatest public health threat to most of the American population.

According to the National Academy of Sciences (1988, p.7), "injury is probably the most under-recognized major public health problem facing the nation today". Injury is defined as "...damage to the body resulting from acute exposure to thermal, mechanical, electrical or chemical energy, or from the absence of essentials, such as heat or oxygen". (National Committee for Injury Prevention and Control, 1989).

In 1990, unintentional injuries were the fourth leading cause of death for all Americans, behind heart disease, cancer and stroke. An estimated 95,000 Americans lost their lives to accidents or unintentional injuries. For Americans aged one to Thirty-seven years, accidents were the prime cause of death, taking approximately 53,000 lives. Accidents also accounted for 9,000,000 disabling injuries, ranging from temporary total disability to permanent impairment (National Safety Council, 1991).

In the past, accident prevention and control concerned special interest agencies of the government such as the National Highway Traffic Safety Administration (NHTSA), and the Department of Labor's (DOL) Occupational Safety and Health Administration (OSHA). More recently, attention has been focussed on injury as a public health problem when the Secretary of Transportation requested the National Academy of Sciences to investigate the injury threat. The Academy's National Research Council, in conjunction with the Institute of Medicine and the Committee on Trauma Research, compiled Injury in America: A Continuing Public Health Problem (National Academy of Sciences, 1985). The report presented a series of research objectives for injury prevention and treatment and provided an impetus for the development of pilot programs in injury prevention. Pilot programs were implemented through divisions of the Center for Disease Control (CDC).

The National Committee for Injury Prevention and Control (NCIPC), a joint effort of the Bureau of Maternal and Child Health and Resource Development (BMCH), NHTSA, and CDC, convened in 1986. The Committee voiced a call to action, reviewing current injury prevention programs and providing an agenda for the continuing development and evaluation of accident prevention programs (National Committee for Injury Prevention and Control, 1989).

Now recognized at the federal level as a major public health problem, injury prevention is gaining support through increased funding for research and development and through the organization of government bodies responsible for monitoring and controlling the threat of injury to the American public.

OCCUPATIONAL INJURIES

The work place is one common environment for accidents. Occupational injuries accounted for 10,500 deaths and nearly one million seven hundred thousand disabling injuries in 1989. Nearly half of all days lost from work are due to accidents, costing 63.8 billion dollars in lost wages, medical expenses, insurance costs and indirect losses (National Safety Council, 1991).

Organized safety efforts for preventing occupational injuries had their genesis in the industrial sector. Increased work hazards, introduced by the Industrial Revolution, lead to major worksite disasters, such as the Triangle Shirtwaist Fire of 1911. Sporadic attempts to control industrial accidents began at the state level near the turn of the century. In 1912, the First Cooperative Safety Congress met in Milwaukee to address the issue of industrial safety at the national level. The following year, the National Council for Industrial Safety opened its doors, providing safety information through publications, posters and films. Shortly, the Council broadened its focus to all areas of safety and changed its name to the National Safety Council.

At the legislative level, Workmen's Compensation laws enacted in 1920 encouraged numerous and varied attempts to ameliorate employee work injuries. The Depression and war years of the next two decades saw little additional attention for safe work environments. Legislative issues focussed on safety issues again in the 1960s when coal mining disasters and mining-related lung disease took the lives of many American workers. The Coal Mine Safety and Health Act of 1969 led the way for the Occupational Safety and Health Act of 1970.

One large industrial group prominent in its concern with safety was agriculture. In 1913, the year of the National Safety Council's birth, the number of deaths from agricultural accidents ranked third, behind railroad construction and mining (Burke, 1976). The National Safety Council published articles on farm safety in the mid-twenties and in 1931 began including agriculturally related death and injury statistics in its yearly statistical report, *Accident Facts*.

The Council's Safety Congress included a farm safety program for the first time in 1937, declaring "agriculture is the largest, oldest, most fundamentally important of the nation's industries; yet it is the only major industry without a safety program of national scope". (Burke, 1976) As a result of the 1937 Congress, a Farm Safety Committee became part of the National Safety Council in 1938. Unfortunately, the comment made in 1937 remains true in many respects today. Farm safety issues have yet to achieve the national recognition, research and treatment necessary to eradicate the threat of injury from the work environment of the farm. There are signs, though, that this is changing.

For example, in 1987 the Society for Occupational and Environmental Health sponsored "Injury Control: Crossroads for the Health and Safety Profession" as the subject for their annual conference. Included was a session "Farm Injuries: A Neglected Problem". And the Institute of Agricultural Medicine and Occupational Health sponsored a 1988 conference which resulted in the report *Agriculture At Risk: A Report To The Nation* (National Coalition for Agricultural Safety and Health, 1988). Today's newspaper headlines read "Farms, Deadliest Workplace, Taking the Lives of Children" (Wilkerson, 1988), "Perilous Profession: Farming is Dangerous..." (Ingersoll, 1989), and "Danger on USA's Farms" (Keen and Walmer, 1989) as articles chronicle the accidents and injuries endured by American farmers and their families. Stories about losing lives and limbs to farm machinery include young children as well as adults. Most farmers say they can supply a list of numerous individuals they know who have been killed or maimed in farming accidents (see Ingersoll, 1989). At last, national attention is beginning to focus on the hazards of an occupation which has long been an American way of life.

Purpose of the Study

There is little direct research in the field of farm safety to accurately guide injury control efforts. This includes a lack of conclusive research on the effectiveness of past farm safety intervention efforts. In particular, the agricultural industry, farm organizations, and farm safety professionals have for years relied primarily on educational methods, but have failed to differentiate between effective and ineffective interventions. Consequently, the applicability of different safety education principles to agriculture are unknown.

However, there is a wealth of research information in other safety and health fields, such as health education, public health, mining and construction safety, and traffic safety. Each of these areas has important guiding principles, but, until now, they have been applied in settings that differ from agriculture in important ways.

Health educators' audiences are found predominately in school and clinical settings. For farm children, the family provides most of the education regarding farm operations. Any safety education received in schools is not likely to overcome the strong influence of the nuclear family at home. Farmers found in clinical settings are likely to be past the point of prevention and in need of medical attention for injuries already sustained.

Public health issues, such as immunization, prevention of drug or alcohol abuse, child car seat use, and the use of vehicle seat belts, gain attention at a national level and potentially involve every American citizen. This makes it easier to involve professionals and the public in intervention efforts. Agricultural safety issues, though, apply directly to only approximately two per cent of the American population, making it difficult to mobilize professionals and the public for a problem that seems non-relevant and remote to the vast majority of Americans.

Occupational safety focuses on an environment where an employer has control over employees and the work setting. There are management structures, and often union structures, in place that provide for the safety and health of workers. In addition, the Occupational Safety and Health Act (OSHA) requires that employers protect employees from hazardous work situations. There are few agricultural safety laws or other internal controls over the farm workplace environment.

This study will review much of what is known about injury control as it applies to occupations other than agriculture and other unintentional injury issues. The authors will evaluate, where applicable, how this knowledge may be applied to agricultural injury issues.

Behavioral change and persuasion research is a field of study that shows some promise to provide empirical valid methods for defining effective injury control intervention methods. Thus, research in the behavioral analysis, modification and motivation areas will be reviewed for its potential application to the understanding of farm safety issues.

It is the purpose of this book to:

1. Review safety issues relevant to agriculture and related fields of safety.
2. Review methods of analyzing and changing behavior.
3. Outline strategies for developing programs to modify farm worker safety behavior.
4. Develop specific recommendations for educators and the agriculture industry on effective means to control farm work related injuries.
5. Identify areas for future research.

Chapter II
Agriculture and Agricultural Injuries

Special Characteristics of the Population and Industry

Why has agriculture lagged behind other dangerous industries in reducing work-related deaths and injuries? The answer is multi-faceted. The farm population is unique in a variety of ways. Characteristics of the farm population and the agriculture industry introduce wide-ranging complications in the effort to reduce safety hazards that result in death and injury.

The Bureau of Census and U.S. Department of Agriculture (1987) paint a portrait of the farm population and the American farm. Over five and one quarter million people, translating into just over 2% of the U.S. population, claimed farm residence in 1986. Half of all farm residents live in the Midwestern states of Illinois, Indiana, Iowa, Kansas, Michigan, Montana, Nebraska, the Dakotas, and Wisconsin. Overall, 43.6% of the land in the U.S. is devoted to raising food and fiber. The average American farm covers 440 acres. However, the range of farm sizes is vast. For example, the average farm size in New Jersey is 11 acres, while the average size of a Wyoming farm is 3,781 acres.

While farms are geographically dispersed throughout a large portion of the country, farming involves only about 2% of the total U.S. population. The small number of U.S. citizens directly in farming makes focussing national attention on the problems of U.S. farmers difficult. The dispersion and accompanying seclusion of individual farmers makes safety consultation and continual exposure to safety education and the enforcement of safety legislation impractical, if not impossible.

Economic Considerations

A greater percentage of farm residents than non-farm residents designate themselves as self-employed or unpaid family workers. Seventy six percent of farm residents, in comparison with 31.7% of non-farm residents, are self-employed or unpaid family workers. In 1985, the median income ($21,853) for farm families was 22% less than the median income ($27,881) for non-farm families (Bureau of the Census, 1987). This was the level of income despite the multiple job holding that is prevalent among agricultural workers. In 1985, nearly half of the cash income for farm households came from non-farm sources. Slightly less than half of all farm operators claim that their primary occupation is farming (U.S. Bureau of the Census, 1987). Workers with multiple jobs are less likely to have the time and inclination to perform farm work safely, or to use safer machinery and equipment on their farms. For instance, an Ohio study (Napier et al., 1985) found farms run by part-time operators had rollover protection on only 15% of their tractors, compared to 26.5% of tractors equipped with rollover protection on farms with full time operators. Simply getting their jobs done, in any way they can, is often the part-time farmer's highest priority.

One of the farmer's most valuable resources is his or her time. Many farming tasks must be performed in a small window of time for the most productive crops and herds. The weather and mechanical implements must all be cooperating to insure timely planting and harvests. If work is slowed down due to the weather or mechanical failures, the time lost translates directly to lost dollars. Sometimes farmers must absorb losses due to circumstances beyond their control, such as drought, plant diseases and other poor growing conditions. Pressure to work quickly can lead to carelessness and oversights that lead to accidents.

Coughenour and Swanson (1983) investigated the effects of multiple work statuses of farm men and women on the labor processes in farm production. They found that off-farm employment does effect the labor and capital process of farm business. Off farm employment of farm women increases the income of the farm, but does not quite compensate for the loss of women's input in farm work. However, off-farm employment for men has a greater negative effect on farm performance because the lost farm labor is much greater and not well compensated for by income from off-farm sources. The financial affects of off-farm work are better understood than the labor affects. Changes in farm work processes caused by off farm employment could affect the safety of farm workers and farm children, however, research has not fully examined non-financial outcomes of off-farm labor. Napier et al. (1985) found that occupationally injured part-time farmers lost more days (20.1) per farmer compared to those lost by full-time farmers (14.8). This might suggest that part-time farmers have more serious injuries than full time farmers, but the difference could also be attributed to availability, cost and quality of medical care, cost and availability of replacement labor, or risk exposure.

Children as Workers and on Work Sites

The majority of individuals working on farms live there as well. Other dangerous industries enjoy the physical separation of the home and work environment. Because the worksite and the homesite are one and the same, accidents on the farm involve individuals who are at work and at play. An alarming number of farm children are hurt or killed yearly in farm accidents.

A survey of farm subscribers of *Successful Farming* Magazine revealed that 65% of farm boys are allowed to drive tractors before the age of twelve (Aherin and Todd, 1989). Large percentages of farm children below the age of 15 are allowed to ride along with parents on tractors, drive tractors and be within 10 ft of rotating parts of machinery. As boys get older, more of them are allowed to engage in these activities, while girls' exposure declines. Unfortunately, most parents perceived low risk for their children in these activities.

The traditional farm culture has involved children in farm work out of economic necessity, the desire to instill a work ethic (Tevis and Finck, 1989) and the cultural mores that farm women should be able to care for their children without outside help (Haverstock, 1989). Under economic hardship, children are often needed as low-cost extra help. Farm women have a variety of responsibilities that include helping with farm work and caring for children. Because of their geographic seclusion and financial considerations, day care is often not an option for farm mothers. Children are often on the work site because they must be supervised while farm production tasks are being accomplished. In addition, improved technology, such as power steering, has made it possible for children to perform basic operations with heavy machinery at younger ages (Aherin and Todd, 1989).

The line between farming as a way of life and as an industry blur where children are concerned. Labor legislation does not apply to children working on their parents farms. The success of many farms have long been dependent on the contributions of the entire family. "The interdependence of farm family members is unique and crucial to a rural way of life (Haverstock, 1989)." Ironically, while the killing and injuring of children from farm accidents is justified in the name of economics and preserving a cherished way of life, future generations of farm producers are lost and the ugly specter of child labor abuse increasingly raises its head.

Aged Workers

Children are not the only age-specific group that represents a unique population of workers on the farm. Just as there are no age restrictions for young workers, there is no particular "retirement age" for farm workers. As used in the following paragraphs, "aged" is defined as those farm workers 65 years of age and over. This age is chosen because it represents a common retirement age for workers in most other industries and, therefore, is useful for comparison purposes. It is recognized that descriptors like "aged", "old", and "elderly" are subjective when applied to any one individual, and that the aging process is actually a life-long phenomenon.

From a safety perspective, symptoms of the aging process first start appearing at about the age of 45 with the onset of presbyopia (loss of accommodation), followed by other changes in vision, hearing, and cognition skills (Monforton et al., 1988). Mental and bodily changes associated with aging are important factors in all three stages of unintentional injury events: avoiding accidents all together; severity and extent of injury in an accident; and recuperation/survivability of injuries after the accident. Aged workers are an important consideration in agriculture as the average age of U.S. farm operators is 52, with 21% of farm operators age 65 or older (U.S. Bureau of the Census, 1987).

As with children on farms, aging farm workers are a part of the culture of farming. Many of the same justifications are used to explain why older persons continue to work on farms, such as availability of labor and economic necessity. But other justifications are more fundamental. For one, many of the older farm operators are the primary owner, manager, and laborer of the farm. To stop farming may mean selling their land, moving out of their home, and giving up meaningful work, changes that have considerable ramifications in terms of self-esteem, pride, and worth.

The case of Uncle Alfred, as told by his grandnephew in Deere and Company's magazine, *The Furrow* (McClintic, 1990) provides a good example of how farmers resist retirement, at least as the concept applies to most other occupational workers. Uncle Alfred, 84 years old, was still putting in 10-hour days. Arthritis and other consequences of aging compelled him to finally sell the farm to a grandnephew under the condition that he could still run a cow-calf herd, help with field work as much as he liked, and could share in crop-management decisions. Uncle Alfred is quoted, "I think retirement is bad for a lot of people....I plan to keep working on the farm as long as the good Lord lets me" (p 32). Uncle Alfred's story and sentiments are not uncommon among aged U.S. farmers.

Decreases in sensory capabilities, (vision, hearing, smell, etc.), information processing and decision-making, and physical and muscoskeletal characteristics all contribute to increased levels of risk for older workers (Small, 1987), and from the study of traffic accidents, age has consistently been found to be one of the higher correlates of accidents (Sanders and McCormick, 1987). A farmer may not be able to distinguish the size and depth of a pot hole in time to avoid it while driving a tractor. Or an older farmer may not have the muscle strength or dexterity to push or move himself away from a horse or cow that is about to run over him. Injury statistics (NSC, 1982; Myers, 1989) show that farm workers age 65 and over have between two and three times the rate of injury, per number of workers, when compared to other age groups.

Stress

Farming is a very stressful occupation. Stress is a physiological and psychological response to elements in the environment. Causes of stress include fear, work overloads or underloads, lack of control, ambiguity, and major life changes (Robinson, 1982). In farming, fear in the form of anxiety and worry, arises from unstable markets, competition and day-to-day economic concerns. Overloads occur at peak times when help is short and the work load is heavy. Underloads occur when doing repetitive, boring tasks and when working alone. Farming is intertwined with uncertain events and elements, such as the weather, outbreaks of disease, and volatile markets. Major life changes contribute to stress because they require adaptation.

Researchers have developed ways of assessing the stressors in a person's life. Weigel (1982) developed a scale of stressful events for farm families by having farm residents rate different events according to how stressful they were. The top stressors include major events, such as the death of a family member; sudden or unexpected occurrences, such as the death of an important animal, machinery breakdown, and outbreaks of disease; uncontrollable events, such as slow downs caused by weather, loss of work time due to prolonged illness; and low level continuous conditions, such as heavy debt loads, poor cash flow, production losses and government regulations.

Elements other than specific events or conditions also contribute to stress. Haverstock (1989), working in a mental health setting with Canadian farmers, describes a more encompassing worry affecting farmers. Many farmers feel that they are losing a way of life and lack control to change their predicament. The family farming tradition is threatened by economic conditions that make it difficult for parents to pass their farms on to their children. Farmers must increasingly turn to other non-farm jobs to shore up their financially ailing farms. Losing the farm represents more to farmers than the loss of a business. It represents losing a way of life and a home as well.

Reactions to stress vary among individual people. Some are affected physiologically by psychosomatic illnesses such as tension and insomnia. Others withdraw by worrying, daydreaming, apathy and sleepiness. All of these reactions to stress can cause decreases in attention, reaction time, and accuracy and judgement in decision-making, leading to injury events (Steffy et al., 1986).

Unfortunately, the direct relationship between life stress and accidents has received little research attention in the field of farm safety. Several studies, however, have found that individuals who have had accidents in industrial settings experienced a significant life event stress prior to their accidents (Levenson et al., 1983) and that work groups experiencing high levels of social and physical stress are more apt to improve their accident rates than other groups when safety recommendations were implemented (Guastello, 1989). It is probable that stress is an important variable in many farm accidents.

Legislation and Farm Safety

The Occupational Safety and Health Act (OSHA) of 1970 mandates safe work environments for employees. However, since 1977, congressional riders on OSHA appropriation bills have prevented OSHA from spending money to promulgate or enforce regulations on farms with 10 or fewer employees. Although not entirely accurate, this limitation is often referred to as the small farms exemption. Exemption from OSHA oversight also eliminates a source of data regarding work accidents. Because small farms are exempt, they are not required to report work related accidents to OSHA, which compiles statistics for other industries.

Legislation that does exist is generally not enforced. The Fair Labor Standards Act for Agricultural and Child Labor requires 14- and 15-year-old children to obtain a certificate for completing the Hazardous Occupations Training Program before operating heavy machinery for hire. Farmers are not punished for lack of compliance to this law (Tevis and Finck 1989; Purschwitz, 1990).

Legislation does not extend to the use of immediate farm family members as laborers. Children working on their parents farm are not covered by the Fair Labor Standards Act for Agriculture and Child Labor. Family workers are not included in the count of employees for OSHA to determine whether a farm is large enough to be included in their jurisdiction.

Farmers themselves have lobbied for the exemption from safety legislation. Farm organizations and farmers in general resist safety legislation. The American Farm Bureau, a voluntary organization of farm and ranch families and the largest farm organization in the U.S., stated the following in its 1977 policy manual (American Farm Bureau Federation, 1977, p. 63):

> "The Occupational Safety and Health Act is detrimental to the American farmer and the American public and is a usurpation by the federal government of state, local and individual rights. The Act does not fall within the responsibilities assigned by our Constitution to the federal government. We therefor favor the complete repeal of this Act. Farm Bureau should take the lead in an all out effort to achieve this important objective".

This stance has moderated in recent years, as evidenced by their 1990 policy manual, "We continue to support an exemption for farms with 10 or fewer employees from Occupational Safety and Health Act (OSHA) regulations". (American Farm Bureau Federation, 1990, p 43). Experienced safety professionals realize this policy statement accurately reflects the attitudes of a majority of farmers.

FATAL INJURIES AND CHARACTERISTICS

WORK INJURY RATES

The National Safety Council (NSC) has a long history of publishing work fatality rates for major industrial groups, and is the most common source for accident and injury data in the United States. The NSC has been publishing estimates of deaths per 100,000 workers by industry group for nearly 60 years. Their most recent estimate for agriculture, which includes agricultural production, agricultural services, forestry, and fishing, was a work death rate of 42 per 100,00 workers (National Safety Council, 1991). This figure meant that the agricultural industry had the second highest work death rate among all major industrial groups, and was 4.7 times higher than the all-industry average of 9. Since 1981, agricultural has ranked either first or second in highest work death rate (National Safety Council, 1991).

More striking is the change in death rates of the three most hazardous industries over the past decade. The death rate for mining, which prior to 1980 had the highest death rate, decreased 55% from 1977 to 1989, while the death rate for construction, the second most hazardous industry prior to 1980, decreased 29%. In stark contrast, the death rate for agriculture dropped only 12% in the same time period (National Safety Council, 1990).

The National Institute for Occupational Safety and Health (NIOSH), a branch of the federal government's Centers for Disease Control (CDC), recently began tracking occupational work fatalities for major U.S. industries. The procedures used by NIOSH differ significantly from those used by the NSC. The NIOSH analyses suggest that the agricultural industry has a much lower work death rate (per 100,000 workers) and ranking than suggested by the National Safety Council. The six-year NIOSH analysis of fatal work accidents indicates a rate of 20.7 for agriculture, which ranked agricultural as the fourth most hazardous industry, and was 2.6 times higher than the all-industry average of 7.9 (National Institute for Occupational Safety and Health, 1989). In an analysis of only agricultural work fatalities, Myers (1989) reported death rates by agricultural industry sector for the years 1981-1985. Agricultural production's death rate ranged from a low of 18.9 in 1983 to a high of 22.9 in 1985. The fishing sector had by far the highest sector rates. The rates ranged from a low of 67.1 in 1982 to a high of 95.1 in 1981.

Agents of Injury

Numerous characteristics of fatal farm accidents have been recorded and analyzed. One of the most common analyses has been a listing of accidents by the type of thing (agent) involved in the injury producing event. Fatality reports from the last forty years have consistently singled out the farm tractor as the specific thing (agent) most often associated with fatal farm accidents, followed by other machinery. In Kansas during 1956, for example, 44% of the total farm work fatalities were tractor accidents, the next largest category was "other farm machinery" which made up 14% of the total (Kansas State Board of Health, 1957). A report by Jensen (1978) showed tractors to make up 40% of Wisconsin's fatal farm accidents in 1976. Machinery was the second leading category with 23% of the total. A five-year summary of fatal farm accidents in Pennsylvania (Murphy, 1985a) identified tractors involved in 50.6% of the cases; machinery was the second leading category with 13.4% of the cases.

When fatal tractor fatalities have been further analyzed, overturns have dominated. One long ago study that pointed this out was by Mclure and Lamp (1961). Their analysis of 212 fatal Ohio farm tractor accidents from 1956 through 1960 showed that an overturn was involved in 57% of the cases. Little has changed in the nearly 30 years since that report. Purshwitz and Field (1987) reviewed reports from several states and found that, as a percent of all tractor related fatalities, overturns ranged from a high of 76% in Georgia to a low of 46% in Minnesota. Karlson and Noren (1979) and Etherton et al. (1989) have reported similar results.

Accidents involving tractors running over operators, extra riders and by-standers are the only other type of fatal tractor accident identified in a number of state reports. For example, in Minnesota 28.6% of the total fatal tractor accidents were runovers (Schultz, 1985), while in Kentucky 15% of these accidents were runovers (Piercy and Stallones, 1984). Generally, the only other type of fatal tractor accident with enough cases to routinely report as a group are tractor power-take-off (pto) entanglements, which make up approximately 5% of the cases each year (National Safety Council, 1991).

In addition to tractors and machinery, other agents involved in fatal accidents include a variety of animals, drownings, falls, burns, suffocations, poisonings, and a large number of cases attributed to the miscellaneous category. Because there are fewer cases to report within these categories less detail is reported, and there is considerably more subset variance within the categories. For example, Field and Bailey (1976) divided their state's fatality cases among 14 major categories. Electrical power was one category, but there was no further breakdown of these cases. Jepsen (1981), on the other hand, reported his state's fatality cases among six major categories. Electrical shock was one of these six, and was further subdivided into five subcategories. A lack of standardization among such reports limits interpretation of this additional data from a national perspective.

Age Characteristics

The age of the victim is another item reported in most analyses of fatal farm accidents. The unique labor aspects of farm work and farm life are revealed by this type of data analyses. Purschwitz and Field (1987) reviewed farm accident studies of fatal accidents to children and to elderly workers in various states. Two states, Minnesota and Indiana, had reported that 24% and 14%, respectively, of their state's total fatal farm accidents were to children 15 years of age or younger. Two other states, Pennsylvania and Wisconsin, had reported that 19% and 24%, respectively, of their state's total fatal farm accidents were to children 14 years of age or younger. Purschwitz (1990) recently reviewed published fatal farm injury rates for children and found rates ranging from 1.5 to 19.0 per 100,000. Purschwitz noted that the rates were calculated in many different ways, and this made comparisons difficult.

Details on fatal farm accidents to children are scarce and, again, marked by inconsistency. Field and Tormoehlen (1982), found that 82% of fatal farm accidents to children (<16) in Indiana from 1970 to 1981 were from tractors (62%) and other farm machinery (21%). Tormoehlen (1986) found similar numbers in Wisconsin; tractors were identified in 40% of the cases and other machinery in an additional 31% of the cases.

Rivara and Stallones both reported considerably lower involvement of tractors and machinery in their studies. Rivara (1985) found one-third of all fatal injuries to children and adolescents (<20) were associated with agricultural machinery; this category was the leading cause of death with the tractor indicated as the most common piece of machinery. Stallones (1989) discovered 30% of the fatal injuries to farm children (<15) in Kentucky were machinery related, but this category was the second leading cause of death. Drownings was the leading cause of death among children with 34% of the cases. As in the two previous studies, of the agricultural machinery cases, the tractor was implicated most often.

Few studies have provided analysis of fatal farm accidents to older workers other than the percent older workers are of a fatality total. Murphy (1985a) reported that 64% of the fatal farm accidents to workers age 65 and over were tractor related. The next largest category was animals which made up 13% of the cases. Purschwitz and Field (1986) found 58% of fatal accidents to aged Indiana farmers were tractor related, with 17% involving other machinery. Etherton et al. (1989), in their six year analysis of agricultural machinery deaths, noted that victims over 50 years of age accounted for 62% of the tractor related fatalities, and that victims over 60 years of age accounted for 44% of the tractor related fatalities. This pattern of fatality to older workers was not seen in any other agricultural machine category. The National Safety Council, in their accident survey report, noted that the 65 and plus age group were involved in 19% of the fatality cases though they only made up 6.7% of the workers in the sample population (National Safety Council, 1982).

Non-Fatal Injuries

Work Injury Rates

Over the past 20 years, there have been dozens of analyses of data collected from states participating in the National Safety Council's Standardized Farm Accident Survey Program (National Safety Council, 1974). These year long, statewide, stratified random sample surveys were organized by the participating state's Cooperative Extension Service and implemented by county Extension offices and volunteers from farm organizations. This data was usually analyzed and reported by each state, as well as forwarded to the National Safety Council for use in their national reports.

Thirty-one states had participated in the survey program by the time of the National Safety Council's last comprehensive report (National Safety Council, 1982). Some of the data categories, however, have recently been updated by data from four additional states that completed surveys. The updated analyses were included in a recent issue of Accident Facts (National Safety Council, 1991). The comprehensive report in 1982 indicated that less than one percent of all injuries reported by the standardized survey program were fatalities; for all practical purposes, analyses generated by the standardized survey program can be considered non-fatal injury statistics. Several injury rates have been generated from the data collected through the standardized survey program. The rates reviewed below were computed from the data of 35 states that have conducted state surveys (National Safety Council, 1991).

Injured victims were placed in one of five age groups: 5 to 14, 15 to 24, 25 to 44, 45 to 64, and 65 and over. The youngest age group had the highest rate of injury with 27.2 injuries per million hours of work. The second youngest age group had the second highest injury rate with 24.4 while the 45 to 64 age group had the lowest rate of injury with 17.8. Generally, hired workers in all age groups had slightly higher rates of injury than family workers, and males in all age groups had higher rates of injury than females. The rate difference between hired male and female workers was much smaller than the difference between male and female family workers. The rate of injury for hired male workers was 26% greater than for hired females; the rate of injury for male family workers was 66% greater than for female family workers.

Injury rates by type of agricultural operation are also shown. The types of agricultural operations analyzed were beef, dairy, grain, fruit, and all others. There was little difference between the four major types of farms. Fruit farm workers had the highest rate of injury with 23.5 injuries per million hours of work, while grain farm workers had the lowest rate of injury with 20.1. Workers for all other types of farms, however, had the lowest rate of injury with 15.6. The reliability of these figures are questionable as about one-half the number of beef farms and three times as many dairy farms were in the sample population as there were in the population as a whole. Grain farms were also slightly over represented.

Agents and Age Characteristics

In a 95 page report titled Occupational Injuries in Agriculture: A 35-State Summary (Hoskin et al., 1988) an analysis of 4,105 work injury cases collected through a standardized farm accident survey program designed by the National Safety Council is presented. There are tables of cross tabulations and accompanying explanations on the who, what, when, where, and how of farm work injuries. Additional facts and figures on major categories of accidents are summarized at the end of the report. Much of what is understood about the nature of farm accidents is contained within this report, and with one exception, will not be further reviewed. The category that will be reviewed is the major source of injury. It is instructive to compare the sources of injury of non-fatal accidents to sources of injury of fatal accidents reported in this report with reports of specialized studies conducted by rural hospitals and trauma centers.

Tractors were involved in only 8% of the total non-fatal work injuries. This placed tractors in fourth place among the major types of agents associated with injuries, and only one-half as involved as other agricultural machinery with 16.3% of the cases. Animals were most often involved with 16.8% of the cases. Remember that with fatal work injuries, most studies show tractors ranking first, with other machinery a distant second. Further evidence that the rank order of tractors and other machinery depend upon injury severity is in Table 16 of the FASR.

When the "thing involved" category was analyzed by severity, agricultural machinery accidents were severe 18.9% of the time, permanently disabling 47.5%, and fatal 13.3% of the time. On the other hand, tractor injuries were severe 8.5%, permanently disabling 7.5%, and fatal 26.7% of the time. The most recent confirmation of the severity of tractor accident injuries was Table 9 in the Huizinga and Murphy paper (1988). Tractor accidents, while accounting for only 5.3% of the total injuries, resulted in an average of 165 work days lost. This was more than six times that of any other source of injury.

Studies from emergency rooms of rural hospitals and trauma centers, which analyze their own data files, generally support the more broadly based statewide surveys. For instance, Stueland and Lee (1989) analyzed 1,413 cases of agricultural injury seen in the emergency department of St. Joseph's Hospital or the adjacent urgent care center of Marshfield Clinic, Marshfield, Wisconsin. Animal injuries were the leading agent of injury with 22.5% of the cases. Machinery was found to be the agent of injury in 7.2% of the cases, and tractors 6.9% of the time. Cogbill et al (1985) analyzed accidents to children (<18) admitted to La Crosse Lutheran Hospital, La Crosse, Wisconsin. The study period was six and one-half years. Animals were the leading mechanism of injury with 40% of the cases, followed by tractor or wagons, 26%, and other farm machinery with 20% of the cases.

Swanson et al (1987) studied farm injuries to 87 children (<19) presented to the emergency room of the Mayo Clinic, Rochester, Minnesota, from November 1974 to July 1985. It was not clear whether these were the total number of cases presented for this age group, or if these were cases specifically selected for analysis. All cases analyzed were tractor and machinery related. Corn augers were the leading category of machine with involvement in 42% of the cases. This was followed by tractors, 25%, ptos with 11.4%, conveyor belts, 5.7%, and other machinery with 15.9% of the cases.

Observations About Farm Injury Statistics

A critical review of farm accident/injury statistics is beyond the scope of this study. However, three important observations can be made about the statistics cited above:

1. There is little consistency among the major groups and agencies currently compiling farm injury statistics. Databases and methodologies for collecting data vary, as do major categories of data presentation, and details of the characteristics of injury agents and injured victims. While there is a positive side to this variability, the variability does make it difficult to clearly communicate the farm injury problem.
2. The statistics cited above are primarily descriptive. Descriptive statistics are an important starting point for understanding any injury problem, but they do not necessarily provide the kind of detail about accident scenarios that are needed to understand or ameliorate a large number of them, or even a particular class of accidents.
3. Despite the problems just mentioned, it is clear that:
   a) Farming is a hazardous occupation.
   b) Tractors are, by a far margin, the agents most often involved in fatal farm injury incidents.
   c) Other machinery are, by a far margin, the agents most often involved in non-fatal, permanently disabling injury incidents.
   d) Young workers and aged workers make up a significant portion of the farm injury picture.

Chapter III
A Review of Injury Control Strategies and Effectiveness

Pioneering Injury Control Strategies

The Three-E Approach

The idea of safety and health has probably existed for as long as man himself. But the written history of safety and health dates back to about 3000 B.C. (National Safety Council, 1991). Most texts associate the beginning of organized safety and health efforts in the United States with the industrial revolution that began in Britain and brought to America in late 19th and early 20th centuries (Petersen, 1975; Hammer, 1985; Teplow, 1987). Initial attempts to reduce accidents to workers in factories, mines, textile mills, the ship building industries, etc., developed out of a common sense approach to eliminating obvious hazards and preventing accidents.

The common sense approach was first crystallized as the "Three Es" approach around 1916 by the president of the Kansas Safety Council, Julien H. Harvey. Harvey observed that the greatest results in accident prevention would be obtained through the use of the three tools - Engineering, Education, and Enforcement (National Safety Council, 1960). This approach directed management to first design, or engineer, the work environment so as to eliminate or guard against accidents. The second tool was to educate and train workers in the use of machinery and equipment to prevent or minimize accidents. The third method was to set rules and regulations which would be enforced, such as rules to wear personal protective equipment.

This approach was the dominant strategy for industrial accident prevention until about the middle of this century. The Three-E approach was very successful in the beginning of the industrial health and safety movement. For instance, Teplow (1987) reported that serious and fatal accidents to employees of United States Steel were reduced 43.2% between 1906 and 1912. Similarly, several other industries and railroads reported accident reductions of between 50% and 66% from their safety programs that were started in the 1890s. Nationally, the frequency and severity of disabling injuries among industrial workplaces decreased almost yearly between 1926 and 1961 (National Safety Council, 1978).

The advent of workman compensation laws in the early 1900s provided a particularly strong inducement for employers to provide safer work environments for employees. The primary safety effort from the period 1900 to 1930 was on improving physical working conditions; this was accomplished mainly by guarding or isolating dangerous machines (DeReamer, 1980). Peterson (1975) referred to this period as the inspection era because physical inspections of the workplace constituted the primary safety effort. Despite improvements there was still considerable dissatisfaction with the rate at which deaths and injuries occurred in the workplace. Heinrich (1959) suggested that the reason too many accidents were still happening was that most accidents (approximately 85%) were caused by the unsafe acts of people rather than unsafe conditions. This proclamation, along with accident proneness studies in England, set off a nearly 30-year attempt by researchers, safety professionals and industrial management to identify workers that were predisposed to having accidents, and on ways to force/convince/cajole workers into working (behaving) more safely.

A practical result of Heinrich's proclamation was that the worker came to be blamed for causing most accidents. As indicated above, considerable effort went into research that tried to understand why workers committed unsafe behaviors, and into safety education programs that tried to alleviate unsafe behaviors. Implied by this research was the notion that it was necessary to understand safety related behaviors to modify or eliminate undesirable behaviors and promote desirable behaviors. Over the last several years, safety and health professionals from many fields have rejected this idea outright, or at best, have given it little credibility (Haddon, 1970; Robertson, 1983; Waller, 1985). There seems little argument among today's safety and health professionals that targeting worker behavior as the primary tool for accident prevention was naive (National Committee for Injury Prevention and

Control, 1989). Targeting the worker, of course, are two of the three legs of the Three-E strategy.

One problem with the Three-E approach was that it focused on the prevention of "accidents". A problem with this focus is that the term appears to be undefinable in a practical sense. Safety and health professionals have yet to come to an agreement on what type of event(s) constitutes an accident. The range of events that are referred to as accidents vary from those that are unintentionable, unavoidable and unpredictable to events that are predictable, avoidable and intentional. Psychologist, the medical profession, safety engineers and educators, the government, lawyers and the public all have their own idea of what class of event(s) are included by the term accident. This lack of agreement has led the safety and health professional in a circle. Safety and health professionals started out studying only events that resulted in injury or property damage, to including "near miss" events that did not result in injury or property damage, to studying errors, mishaps, near misses, and behavioral maladaptations. Modern thought now suggests we look at injuries from the view point of being understandable, predictable and preventable events (National Committee for Injury Prevention and Control, 1989).

Another problem with the focus on accidents was that as safety professionals and industrial managers tried to apply the Three Es, the idea came into being that if a hazard was identified it had to be eliminated, reduced, or somehow controlled. Since the Three Es evolved out of the industrial safety movement, its application was most useful within industrial settings. But as our industrial settings became more complex and varied, safety professionals found that the Three Es weren't as easily implemented, nor could they produce as effective results, when applied to newer industries and in different work situations. Underlying the effectiveness of the early efforts of industrial safety was a control of the work setting and workforce that doesn't exist in many workplaces or with many occupations today.

To briefly summarize the Three-E approach as an accident control strategy, early efforts by employers concentrated on the guarding of hazardous machinery. When this activity became less effective at reducing accidents, the focus shifted to blaming workers for causing accidents, and in trying to modify their behavior. This focus, too, did not produce the kind of results that were expected. From 1961 to 1976, injury frequency rates nearly doubled and severity rates leveled off (National Safety Council, 1978). Few current academic or professionally trained safety and health experts still use the Three-E approach as a guide for accident or injury control.

Human Factors Engineering

Textbooks refer to Human Factors Engineering (HFE) in many different ways and by many different names. For instance, HFE is also called ergonomics, human engineering, human factors, engineering psychology, bio-mechanics, and bio-engineering, among others. Sanders and McCormick (1987) consider the three most common terms of ergonomics, human factors, and HFE as essentially synonymous, and believe that any distinctions among the three are arbitrary. For the purposes of this discussion, HFE is defined as the field of study that is concerned with ways of designing tools, machines, jobs, operations, and environments so that they match human abilities and limitations. To use other words, the central concept of HFE is that it is the designing and constructing of systems and tasks to fit the characteristics of people rather than retrofitting people to fit the task or system.

Surry (1977) noted that an essential point about HFE is that man and his environment are inseparable and that man's behavior is a result of past and present interactions with his surroundings. For this reason the study of human factors in accidents cannot divorce itself from these interactions and must constantly refer to them. It follows, then, that to understand the broad field of HFE is to understand how this field of study is considered to be a broad based approach to accident control.

The development of HFE as an approach to accident control, like the Three-E method, traces its history to the industrial revolution but it did not become recognized as an organized approach to accident control until the time of World War II. Dhillon (1986) credits Fredrick Taylor and his study in 1898 of the best designs of shovels and the optimum weight per shovelful as the first HFE study, while Sanders and McCormick (1987) start their early history review of HFE with Frank and Lillian Gilbreth and their work with bricklaying and hospital surgical teams in the early 1900s. The type of studies Taylor, the Gilbreths and others after them did became known as time and motion studies, and the people that did the experiments were called time and motion engineers. The time and motion engineer is the predecessor of the modern human factors engineer.

The primary emphasis in time and motion studies was on the person as a worker; that is, as a source of power. It wasn't until World War II that a new category of machines appeared – machines that made demands not on the operators muscle power, but upon their sensory, perceptual, judgmental, and decision-making abilities. The job of radar operator, for example, required virtually no muscular effort but makes severe demands on sensory capacity, vigilance, and decision-making.

As a result of the technological advances that resulted from World War II and the period that immediately followed, many unfortunate experiences showed that workers simply couldn't keep up to the demands that the newer, faster, more complicated machinery, systems, tasks, processes, etc., were making. As a consequence many errors were made, and some of these errors lead to accidents and injuries. Thus a new group of scientific experts emerged that dedicated themselves to the integration of the human element into new and complicated machine systems. As a result of their efforts, their practices emerged as an organized approach of accident control. It is important to understand that HFE is not solely concerned with safety. Other goals or objectives of human factors engineers are efficiency, reducing fatigue and boredom, increasing comfort and convenience, and increasing reliability among others.

HFE is not an exact science but it is a scientific approach to designing and constructing the things that people use. It draws upon the sciences of engineering psychology, biomechanics, physiology, industrial hygiene, medicine, and others. It is in large part an empirical science of how people see, hear, think, react, and how big, how small, how strong, how fast, etc., people are primary concerns. Human factors engineers are not worried about distinctions between errors and accidents (Chapanis, 1980). To them there is little significant difference between an error and an accident. The important thing is that both errors and accidents signify or identify a troublesome or potentially dangerous situation.

Systems is an important concept in HFE. There are many types of systems but in the context of HFE, a system is an orderly arrangement of components that interact to perform some task in a given environment. The system has a purpose of accomplishing some task or function. HFE is often referred to as the study of operator-machine and operator-environment systems with most of the emphasis on the man-machine interaction that takes place within some given environment. Within the man-machine environment, man is viewed as a sensor, as an information processor, and as a controller. As a sensor, man is basically seeking out information that will help guide their decisions. Often they are seeking out information from displays of some sort. A display can be any of a thousand different things –the position on a dial, the readout of a digital computer, sound from a speaker, a red light flashing, or the feel of a certain kind of control.

Having sensed or sought out information, we then have to interpret the information, understand it, perhaps do some mental calculations and reach a decision. This is man acting as an information processor. In doing this we often use another human ability–memory span–to compare what we remember about past experiences, or to recall operating rules we learned during training. The areas of concern in information processing are information overload, perception, memory, and learning among others. After having reached a decision, we usually take some action, and usually the action is exercised on some control such as a push button, lever, pedal, switch, handle, etc. Action on these controls then results in some action by a machine, output from a machine is produced, or maybe there is a change in the machine's display. All of this is happening within some physical environment that itself is providing or impeding sensory information, is interfering or distorting the processing of information, or interfere or inhibit control actions that the person wants to take.

Today, HFE is a common and integral part of most modern day consumer products, farm and industrial machinery and equipment, plant and office building layouts, assembly lines, military and aerospace hardware, motor vehicle designs, etc. It seems entirely reasonable to credit a large part of the continual reduction in overall accidental work death rates and occupational work death rates (National Safety Council, 1991) to the application of HFE principles and guidelines by U.S. industries and businesses. This doesn't mean there isn't room for improvement. Indeed, it seems that society in general, and workers in particular, are never satisfied with current levels of safety and health. Though the HFE approach to accident control has offered a way of addressing many of the shortcomings of the Three-E approach, some basic limitations are inherent.

HFE has some of the same problems of the Three-E approach in that its focus can be very broad within the context of safety and health. For instance, HFE addresses errors and mishaps, but the question must be asked, "Which errors and mishaps?" All. Or only errors that lead to injury? If so, do we mean only serious injuries? To what degree do we attempt to control errors? What are the costs and benefits involved? How much is a person's life worth? It soon becomes apparent that focusing on errors can quickly become unwieldy because no one is perfect, least of all the human being, and there is little agreement in society for the questions just asked.

To apply HFE requires control over subjects, machines, and environments that may not exist in some workplaces, or with some occupations or industries. Agriculture is perhaps the best example of an industry that is not conducive to typical work force or workplace controls. Because the human being is such an indivisible part of HFE, this approach to accident control will never be as completely reliable, dependable, or predictable as we would like.

The Public Health Approach

Public health approaches to accident control come from a fundamentally different perspective than the Three-E and HFE approaches. The two previously discussed approaches evolved from workplace experiences of workers, usually in specific industries or occupations, and were reactions by employers whom had various economic incentives to avoid or reduce accident losses. Public health practitioners, on the other hand, approach accident control from a population medicine perspective, and use the science of epidemiology as the cornerstone for understanding, preventing, and controlling accidents and injuries.

The field of public health developed out of a concern for one, preventing ill effects of diseases, and secondly, for the spreading of diseases among individuals and communities. The first connection between public health and injury prevention is said to have come from Germany in 1789 when a public health pioneer, Johann Frank, opinioned that injury prevention was a legitimate area to be addressed by a nation's public health programs (Waller, 1989). Despite this early reference, there is little evidence that the public health community, particularly in the United States, took a comprehensive interest in accident or injury prevention until the last few decades. *The Injury in America* report, published by the National Academy of Sciences (1985), acknowledged that injury epidemiology is a "young scientific field with a theoretical basis within the wider framework of epidemiology" (1985, p. 25). Interestingly, similar sentiments were expressed almost 30 years ago (Fox, 1961a, p. 377) in a book discussed below.

One of the first comprehensive treatises on accidents and injuries as a public health problem was *Accident Prevention* (American Public Health Association, 1961) by the Program Area Committee on Accident Prevention, a committee of the American Public Health Association. Chapter 3 of this book is titled "The Epidemiology of Accidents" and was written by McFarland and Moore of the Harvard School of Public Health. This chapter's focus is how the epidemiological model could be applied to accident causation and prevention. Part of their discussion is about the difficulties caused by the lack of an acceptable definition of "accident". At the same time, other public health researchers were also publishing papers on this point (e.g., Suchman, 1961; Fox, 1961a). The reason for presenting this information in this study is that the public health approach, though fundamentally different than the Three-E and HFE approaches, was stymied, at least up until this point in time, because they too were focusing on the prevention of "accidents", and how to manipulate the behavior of people to stop having accidents (Waller, 1989).

The works of Hugh DeHaven, John E. Gordon, James F. Gibson, and William Haddon, Jr., between 1942 and 1980 have been credited with moving the public health approach to injury control beyond a focus on accidents and the people whom caused them (Waller, 1989; National Committee for Injury Prevention and Control, 1989). Specifics of the modern day public health approach to injuries and their reduction will be presented in a later section. But important to mention in this section, is that few public health professionals continue to use the term "accident prevention" to describe the discipline they are working in, preferring instead, to use the term "injury control (Vilardo, 1988). What has not changed, though, is the use of epidemiology as the basis for the science of injury control. Thus, it is important to review epidemiology and its use for injury control.

Epidemiologists cast the injury problem in the same epidemiological framework used to study and treat diseases. That is, the cause of injuries (diseases) is considered an interaction of three components: the host, the agent, and the environment. Descriptive epidemiological techniques are used to discover the amount and distribution of injuries within a population by person, place, and time; analytical epidemiological techniques are used to study the determinants or reasons for relatively high or low frequency in specific groups (Mausner, Kramer, and Bahn, 1985). The assumptions of epidemiology are one, that injuries are not randomly distributed throughout the population but that subgroups differ in the frequency of different types of injuries. Secondly, that knowledge of this uneven distribution can be used to investigate causal factors and therefore lay the groundwork for programs of prevention and control.

The success of epidemiology in disease prevention has had a far reaching effect on the health of today's citizens (Rothman, 1986). Fluoride supplementation in water has reduced dental decay, risk factors for cardiovascular diseases, the connections between smoking and lung cancer, tampons and toxic shock syndrome, low level ionizing radiation and leukemia, are just a few of the success stories involving epidemiological approaches to public health problems. Whether epidemiology can have the same kind of large-scale success with injury problems remains to be seen. Vilardo (1988) points out some potential problems with the wholesale application of epidemiological principles to injury prevention problems. His primary points are first, that injuries are multicausal; that is, injuries have much longer chains of causation than do most diseases. Secondly, past successes of disease epidemiology stem primarily from interventions between undesirable outcomes and undesirable behaviors. Vilardo points out that injuries are often the result of behaviors that individuals consider desirable, thus the motivation to change or alter behavior is missing. A third problem is that many other successes of epidemiology have resulted from a one time application of countermeasures. For instance, many diseases are immunized by means of a single or very few vaccinations. It is not likely that there will ever be a vaccination to protect against injuries.

Current Strategies to Injury Control

Conceptual Foundations

The current approach to injury control has been evolving for the past 20 years, and only today are the concepts and principles gaining wide publicity and acceptance. The current approach combines empirically proven principles and concepts of HFE and epidemiology with historically learned lessons from previous injury control approaches.

One of the more useful principles from HFE is that potentially hazardous environments should be modified or arranged to prevent or limit the damage that might possibly be inflicted upon workers. Similarly, a most useful principle from epidemiology is the concept of intervening between interactions of the host, agent and environment. Gibson (1961) was the first scientist to conclude that injuries to a living organism could be classified according to the forms of physical energy involved, and identified these forms of physical energy as either mechanical, thermal, radiant, chemical, or electrical. Haddon (1963) extended this observation to include negative energy such as a lack of oxygen.

Haddon (1968) discussed structural damage and death from accidents as a social concern, and noted that as with polio, there were essentially three major portions or phases of sequences of events leading up to the undesired end results. Furthermore, during these three phases causal factors were active and countermeasures could be undertaken. In 1970, Haddon used the concept of physical energy as the agent in injury events, and developed 10 strategies for reducing losses from transfers of energy that caused damage (see the Appendix for a complete listing of the 10 strategies). An agent, as defined by Haddon, was an entity whose action is necessary to produce specific damage, and, without which, the specific damaging event does not occur. Thus, mechanical, thermal, radiant, chemical, electrical, and, in certain situations, lack of energy are the agents of injury in any accident.

In 1972, Haddon, writing about a logical framework for categorizing traffic safety phenomena and activity, used the terms pre-event, event, and post-event to describe the phases of accidents. Additionally, he identified humans, vehicles and equipment, and environment as the three factors involved in each phase of an accident. By crossing the phases with the factors, the Haddon matrix was formed.

The latest extension of Haddon's work (Haddon and Baker, 1981) provided a matrix that could be used as a tool in developing accident prevention strategies. The classic host/agent/environment interaction is separated more definitively into the host, the vector or vehicle, the physical environment and the sociological environment. The time factor is added allowing strategies to be examined before, during and after the injury event. Crossing the time factors by the host, vector, and physical and sociological environments, yields twelve different areas where injury prevention strategies can be employed.

Haddon's work identifies the possible methods of injury prevention, intervention and amelioration. The matrix and strategies he developed are intended as an aid to cognition, judgement and consideration when attempting to address a particular kind of injury. The strategies and matrix are not presented as nor intended to be a "cookbook" approach to treating an injury problem. Haddon emphasized the fact that his strategies do not rely on the actual causes of injury, "but rather on the means available for reducing...undesirable morbidity and mortality which is a substantially different matter indeed". He continued:

> "...reductions in undesirable end results can often be achieved without an exhaustive knowledge of their exact causes. In illustration: pasteurization and water purification can control milk and waterborne diseases even in the absence of specific knowledge as to which pathogens would otherwise reach publics to be protected; evacuation of residents from the vicinity of a chemical plant fire can protect them from toxic materials even though no one may have specific information as to which agents are present; and the use of guards and electrical insulation can prevent injuries regardless of the state of knowledge of the reasons people come into contact with the machines and wires that are so shielded" (Haddon, 1980, p. 418).

Haddon's philosophies and concepts are widely embraced today, and guide much of the current thinking on injury prevention and control. But there is more to the current approach than just Haddon's concepts. As Haddon himself explained, his strategies and matrix are not a per se means for choosing injury control policy, but rather a means for identifying, considering and choosing the various means by which policy might be implemented (Haddon, 1980). A more complete understanding of current approaches is had by examining the means and methods by which safety and health advances over the last several decades have actually been achieved in the United States.

Broadly based reviews of the methods for enhancing safety and reducing hazards in the United States have found three distinct means for achieving safety and health. Robertson (1983) refers to the three as (a) educating and persuading individuals, (b) laws and regulations directed at individuals, and (c) policies directed at agents and vehicles of injury. The National Academy of Sciences (1985) used similar descriptors which included (a) persuade individuals, (b) require individuals, and (c) provide automatic protection) in their report. And the National Committee for Injury Prevention and Control (1989) reiterated these three means with their categories of (a) education/behavior change, (b) legislation/enforcement, and (c) engineering technology.

Though cast in slightly different terms and groupings, a thorough reading of these three documents reveals little substantial difference in terms of classifying past and present methods for achieving safety. There is little argument among recognized safety and health professionals that effective injury control for many safety problems requires some mix of all three approaches, often applied simultaneously. Each of the three methods will be discussed briefly with most of the major discussion points derived from Robertson's (1983) text.

Educating and Persuading Individuals

A basic American cultural theme is that enough education will resolve almost any problem (Robertson, 1983). The tendency to attribute injuries to 'human error' has for years provided the fodder for layman and scientist alike that injuries can best be prevented through voluntary behavior change. The voluntary changes are intended to be brought about through persuasive safety education messages and programs. In safety education and training, a mixture of information and skill training attempts to change the attitudes and behaviors of individuals. For education and training to be effective, its assumptions must be valid. Four assumptions underlie the theory of safety education.

(a) Persons informed of the risk will retain the information and take the recommended action to reduce the risks.
(b) Persons skilled in a given hazardous endeavor are less likely to be injured than those less skilled.
(c) The educator has the means available to teach information or skills, and to cause behavior change related to emotions, attitudes, and values.
(d) The training of people to perform hazardous activity will not result in an increase in the activity to the point that any injury reducing effect is offset by increased injuries resulting from use of the new skill.

Empirical data and experimental research suggest that often one or more of the underlying assumptions of safety education are false for any given education or training program. Another major problem with this method is that despite the large body of research on human behavior, individual traits that are easily modifiable for injury control have so far not been identified. The counterproductive influence of the mass media, a lack of control over workers, the inability to control reward and punishment contingencies, democracy, and American heroes are just some of the divergent explanations why education/persuasion has not been more successful in reducing unwanted safety behaviors and increasing desired safety behaviors.

Yet for practical, political and economical reasons, safety education will continue as a major means for achieving injury prevention and control. Safety education has always served as the bridge linking the real world of hazardous conditions, processes, and products with the ideal world where all things are completely safe (Murphy, 1985b). It is often the easiest and quickest method of injury control to implement, and it does take advantage of people's capability to perceive, improvise, and apply originality to new and reoccurring problems.

Robertson (1983) reviewed safety literature in many fields and found instances where education/persuasion measures had a positive effect. In studies where education/persuasion showed evidence of a lasting, permanent positive result, one or more of the five following characteristics were found.

(a) Only a single action by an individual at a relatively low cost (effort, financial, etc.) was required.
(b) Information as well as simulation of the consequences of unsafe acts was provided.
(c) Feedback on safety measures taken and their effects on overall injury rates was provided.
(d) Frequent rewards were continued indefinitely and were given to those individuals who maintained their safety measures.
(e) Inspections were done to ensure that individuals followed the safety procedures outlined.

Ensuring that these kinds of characteristics are consistently employed in agricultural safety and health education programs are at the least difficult, and most often impossible. One major limitation noted in various studies was that education/persuasion worked least on groups or individuals that needed it the most.

Laws and Regulations Directed at Individuals

Education/persuasion by itself has rarely proved to be an adequate preventative approach. An alternative strategy to safety education is to require or prohibit certain behaviors by law or administrative directive. These types of laws and rules may be designed to either deter safety related behaviors, or to increase self-protective behaviors. An example of a Law that attempts to deter behavior would be that it is against the law to drive while intoxicated, seem to be more politically acceptable than laws promoting self-protective behavior, like seat belt use laws. Usually the behavior prohibited by the deterrence type laws is perceived as a greater threat to the public in general, as well as to an individual, than behavior that is proscribed by self-protective laws.

In general, studies have shown that individuals are most likely to comply with safety laws and rules that contain the following elements or factors.

(a) The behavior would be a part of the individual's normal repertoire of behavior irrespective of the laws or rules.
(b) There is a high individual propensity to conform with the law or rule on moral or ethical grounds.
(c) There is a high probability of detection and conviction of persons that do not comply.
(d) Compliance does not interfere with comfort, convenience or pleasure.
(e) Few exemptions are allowed.
(f) Enforcement can be augmented by persons other than the police.
(g) Observation of regulated behavior by authorities is easy.
(h) There is a perception of increased concentration to detect nonconformity.
(i) Conviction occurs soon after detection of nonconformity.
(j) Conviction results in severe penalty.

Policies Directed at Agents and Vehicles of Injury

Policies directed at agents and vehicles of injury generally exist in one of two forms. Either rules and regulations are issued by some government entity affecting products or processes, or designers and manufacturers of products and processes voluntary meet design or performance criteria. Both avenues have as their goal hazard elimination or reduction for specific products and processes.

This means for achieving safety is universally credited by safety and health professionals, safety organizations and safety standards groups as the most effective way to achieve injury control. Not coincidently, this type of protection is the essence of the "engineering" approach discussed earlier. Barnett and Brinkman's (1986) review of safety hierarchies is further evidence of the unanimity of opinion from all sectors of the safety and health profession.

Most injuries to humans involve contact with products, machinery, equipment, structures, surfaces, etc. Throughout history, laws, regulations, and standards that automatically eliminated, reduced or control the damage an agent can inflict have proven to be most effective in preventing and limiting the damage to humans from potentially harmful agents. Some of the common examples where this strategy has been used include:

Motor vehicles—crash worthiness of vehicles, air bags, padded dashboards and steering wheels.

Consumer products—Toy safety act, standards for playground equipment, Poison Prevention Packaging Act, Lawn Mower standards.

Agricultural machinery—ROPS and the Machinery Guarding Standard.

The goal of this strategy is to provide automatic protection regardless of behavior. The more automatic the protection, and the less it requires participation by the human to be operable, the more effective this approach. Application of this strategy can be utilized regardless of who is at fault for a given class of accidents, and without understanding all of the nuances of the "causes" of injury events. The effectiveness of policies directed at agents and vehicles of injury is dependent on technological and economical feasibility, political acceptance, and the extent of compliance with rules, regulations, and standards.

Use of Incentives

A number of studies support the contention that incentives promote industrial safety. An Australian company found a reduction in reported accidents from an average of 116 to 10 per year (Cohen et al., 1979); they used gifts contingent upon group accident rates as the incentive. One company had incentives contingent upon reaching specific monthly and quarterly safety related goals. They used awards in the form of points exchangeable for goods for attaining the goals. In this study, Bodycombe (1986) found an 81% reduction in work related accidents. Freeman (1972) found that a company using a similar approach had a reduction in reported accidents from 114 to 3 per year. A mining company used trading stamps to reward reduced accident rates. They noted a 50% reduction in reported accidents over a 5 year period (Fox, 1976). The successful programs were ones in which specific, clear goals were employed.

Critics of the incentive programs just described claim that accidents are not really being reduced; employees are just not reporting accidents in order to meet their safety goal. Because of this potential, some professionals do not feel incentive programs, as practiced in industrial settings, are an ethical approach to accident reduction.

The above discussion does not mean that safety incentive programs are completely without merit. Indeed, incentives have great potential for reducing accident rates, if the incentive is behavioral oriented. That is, goals should not be related to accident reduction but to the performance of safe behaviors. One behavior that has been changed by incentives is seat belt wearing (Ellman and Killbrew, 1978; Geller, 1983a). Some of these studies even noted response generalization. That is, when prizes were given for afternoon belt use, workers increased their morning belt use also (Geller, 1983a). However, when incentives were taken away, belt use behavior quickly regresses back to baseline. Major shortcomings of safety incentive programs in occupations like agriculture are the ability to observe safe behaviors and maintenance of long-term award systems.

Agricultural Approaches to Injury Control

Past and current efforts for modifying farm worker safety behavior can generally be grouped into education, engineering and legislative activities. Most intervention efforts have been organized around specific injury agents, such as tractors, harvesting machinery, animals, and toxic dusts and gases, or around specific groups of farm workers such as children or migrant workers. Engineering and legislative efforts to reduce common hazards and types of injuries have generally included an educational program to get the message out to the farm population. Almost all efforts to reduce hazards and to modify farm worker safety behavior are marked by a lack of an evaluation of the program's effectiveness.

Education

Farm safety education, as a nationally organized and enduring movement, began in 1942 with the holding of the first National Home and Farm Safety Conference by the National Safety Council (Burke, 1987). Farm safety education became a permanent part of the National Safety Council in 1944 with the naming of the Farm Division as a separate department. At about the same time, other people and groups were organizing for the promotion of farm safety. Individuals specializing in farm safety met for the first time in 1945 at the National Safety Council headquarters. This meeting resulted in a series of annual meetings that were called "institutes". These institutes, in turn, grew in 1962, into the National Institute for Farm Safety, Inc. (NIFS) a professional organization for agricultural safety and health experts. The American Farm Bureau Federation, the Farm Equipment Institute (currently known as Equipment Manufacturers Institute), mutual insurance companies and several state level groups were also active in promoting farm safety at this time.

Most early day farm safety experts were employed by state cooperative extension services, state farm bureaus, agricultural machinery manufacturers, and mutual insurance companies. The majority of these individuals either had degrees as agricultural engineers, or were managers of insurance companies. Irregardless of organizational affiliation or educational background, farm safety experts of that era firmly believed that education was the key to reducing farm accidents. There were no significant safety laws that applied to farming during this time, and so the farm safety movement was considered to be voluntary. That is, farm workers were free to heed or ignore farm safety suggestions as they saw fit, and the groups and organizations that sponsored farm safety educational programs and information were also doing so on a voluntary basis.

A publication titled Farm Safety Review, published by the National Safety Council in 1943, marked the beginning of large scale, nationally organized efforts at farm safety education. This was followed by the first National Farm Safety Week campaign in 1944. By 1945, farm safety education was in full swing as safety bulletins, posters, leaflets, booklets, radio spots, magazine articles, etc., were used to spread farm safety messages. Farm organizations, the US Department of Agriculture, 4-H clubs, FFA chapters, and other community groups were all enlisted in the farm safety education effort.

The overall effort for farm safety education grew throughout the 1950s and 1960s. More farm safety specialists were hired by state cooperative extension services, statewide farm safety committees were formed, the distribution of National Farm Safety Week materials increased, and radio and TV were increasingly used to spread awareness of the need for safe farm practices. The farm safety education effort reached a crescent in the mid to late 1970s. This was the result of the USDA Cooperative Extension Service budget appropriation that included seed money for each state to hire an Extension farm safety specialist. This allowed existing Extension farm safety programs to expand, and new programs were started in states that did not have full time safety programs. Even at its apex, however, the level of farm safety activity was minuscule compared to other identified hazardous occupations such as mining and construction. For instance in mining, one supervisor for every 25 workers is the norm, and workers are checked on twice a day.

Farm safety education in the 1980s resembled the U.S. economy. Inflation, coupled with a flat level of funding by USDA, resulted in many states dropping or severely curtailing their farm safety efforts by the mid 1980s. Additionally, the National Safety Council significantly reduced staff in the Agricultural Division, and the safety leader position within USDA was vacant for much of the time, or filled with a one-half time appointment. Despite these declines, the last half of the 1980s has seen several new players enter the farm safety scene.

Nearly all of the new players have been associated with public health and the medical profession. For instance the New York Center for Agricultural Medicine and Health, a part of Bassett Hospital, Cooperstown, New York, and the Institute of Agricultural Medicine and Occupational Health, a part of the University of Iowa, Iowa City, Iowa, co-sponsored a "policy strategies for the future" conference in 1988. The National Institute of Occupational Safety and Health also became interested in agricultural safety issues in the mid 1980s. Nearly all of the activities by these groups has involved data collection on farm injury and health problems, and conferences, workshops, and publications to increase understanding and awareness of farm safety issues and problems.

There are few studies in the literature that address whether or not specific educational programs have been effective in reducing the incidence of farm accidents and injuries. Silletto (1976) and Williams (1983) found no evidence that participation in tractor and machinery safety education courses lowered youthful tractor and machinery operators' risk of accidents. Both of these studies used accident involvement as their criterion. Murphy (1985b), using more specific knowledge and behavioral criteria, found evidence that vocational agricultural students increased safety knowledge; several subjects retained safety knowledge for two to three weeks after educational programs; and 25% of the students effected some type of behavioral change as a result of the safety education program. Though not testing a specific program, Schafer and Kotrlik (1986) discovered that farmers that had participated in a farm safety program had higher safety index scores. Several studies were located that failed to find a positive relationship between reduced accident involvement and higher levels of formal educational attainment. But these are not included in this study because they did not involve the evaluation of specific safety educational programs.

In a different vein, Colorado State University received funding in 1977 from the W. K. Kellogg Foundation to develop a five year safety and health demonstration project. This project was to address the needs of the agricultural and small-business communities (Colorado State University, 1982). This program involved on-site consultation surveys, and an extensive evaluation of all goals and activities was undertaken. In writing about that experience, Blehm (1989) noted that efforts to make surveys available to the independent producer met with complete frustration. The few farmers that did participate in the surveys indicated they probably would not request such service if they had to pay for it.

Bayer (1984) reported on the success of a farm that implemented a comprehensive farm safety program that combined five key elements of successful industrial safety programs: management commitment, a written safety policy, an award and incentive program, safety committee involvement, and continuous feedback to employees. Safety training and education were an integral part of the overall program. After five years, results included a substantial reduction in the number of accidents, a cutting of the average cost per accident in half, and a lowering of total accident costs by one-third. Becker and Shoup (1986) studied a large citrus grower in Florida that had a comprehensive safety program for several years, and compared loss data from this grower with the average losses of all citrus growers in Florida. The authors concluded that first, the safety program, on a pure cost basis, appeared to have saved about two to three times what it cost. Secondly, that during key weather periods, the man-days saved from fewer accident time losses could increase marginal profits 10 to 20 times over the cost of the safety program. These programs were implemented on large farms who had a management structure very similar to many industrial operations. That is there were managers, supervisors, a large number of employees who worked under a supervisor and a safety committee who had management support. Thus, these studies illustrated that this type of program has the potential to work well on large farming operations of this nature. But the ability to apply this system to smaller farming operations would not be practical for most operations.

Other than the studies cited above, the authors found no published articles on specific farm safety education program effectiveness. It is easily concluded that farm safety education is largely a patchwork of unscientific inclinations and intuitions as to what may or may not be effective programs and program elements. Twenty years ago Klein and Waller (1970) wrote about the problems of educational countermeasures (programs) becoming entrenched before there were systematic evaluations of their effectiveness. They noted that a fundamental problem with most safety educational endeavors was that a corps of practitioners always arose who had a vested interest in the continuation of the status quo. That is, there are economical, political, and emotional motives associated with the development, promotion, and use of safety education materials and programs. The longer certain types of programs and materials are used, the more resistant are proponents to engage in scientific evaluation. The evidence from the agricultural safety and health educational field suggest that Klein and Waller's message was unheard.

Engineering

Eliminating and reducing hazards by the application of new technology to products and processes has long been a primary method of injury prevention in the agricultural industry. The promulgation of safety and other standards by the American Society of Agricultural Engineers (ASAE) is the primary means by which the manufacturing industry has produced safer tractors, machinery, and related products. The first concerted effort by agricultural engineers to reduce a safety hazard was in the 1930s; this resulted in a standard dealing with shielding for the tractor rear pto. There was little additional safety standard activity until the 1950s when several new standards included safety. The number of standards including safety, or that were primarily safety, multiplied during the 1960s and 1970s, and continues today.

The motivation for developing agricultural engineering standards has been, like farm safety education, a voluntary process involving a number of interested groups. The accommodation of a variety of industry, academic, and public interest viewpoints means it usually takes years to get a standard or engineering practice adopted. Compliance with adopted standards by manufacturers is also voluntary. The nature of the voluntary consensus standards process, combined with a capitalistic economic system, and an unorganized, relatively disinterested user group (farmers), has resulted in only small, incremental increases in safety for farm workers over the past 30 years.

One example is provided by the issue of pto guarding. In 1930, W. Leland Zink called for "the elimination of projecting parts such as set screws, bolts and pins" in his paper calling for standardization of the pto for farm tractors. This problem was not addressed in the pto standard and recommended practice revisions of 1931. Although this standard has been reviewed and revised many times in the intervening 53 years, the 1990 American Society of Agricultural Engineers standard (ASAE, 1990; SAE S318.10, Section 8.4.1) still allows the types of protrusions Zink identified.

Another example is with rollover protection for tractors. ASAE S305, Operator Protection for Wheel Type Agricultural and Industrial Tractors, was adopted in 1967. This standard was superseded by S383.1 in 1977 and is commonly referred to as the ROPS (rollover protective structure) standard. A 1987 (Huizinga and Murphy, 1987) study found less than 20% of the state of Pennsylvania's farm tractors fitted with a ROPS. Up until 1985, manufacturers left the responsibility of equipping farm tractors with ROPS up to the purchasers of the tractors. Since 1985, American manufacturers have been voluntarily equipping all farm tractors (over 20 hp) with a ROPS unless the purchaser specifically refuses the ROPS. Due to this action the percentage of tractors with ROPS will increase gradually with time as the older non-ROPS tractors are removed from the market place.

The hazard reduction possibilities of some engineering standards are rendered almost useless in the workplace because the manufacturer loses control of the product once it enters the market place. Farm workers often remove tractor pto master shields and implement pto driveline shields. On-going studies at Purdue University (Campbell, 1987) suggest over 50% of tractor master shields and implement driveline shields are missing or are severely damaged. Agricultural equipment dealers are not known to actively promote safety devices (Fogerty, 1989), and often have unguarded machinery for resale (Campbell, 1987). There are no standards applicable when farmers resell machinery and equipment directly among themselves.

Critics charge that agricultural machinery manufacturers are slow to utilize hazard reduction technologies common to many other industries (Sevart, 1987). Examples are the lack of interlocking guards on power transmission shafts and gears, emergency stop devices on machinery or particular machinery parts, and automatic reversing of material intake components. Others (Anderson and Smith, 1988) argue that such devices are not proven effective in agricultural environments. Arguments on both sides of this issue are largely subjective as there is relatively little public research in these areas. Only a few studies were found in the literature that evaluated the effectiveness of engineering innovations to eliminate or reduce specific hazards. The Slow Moving Vehicle (SMV) emblem was found to significantly reduce accidents involving motor vehicles and farm machinery on public roads (Secretary of Transportation, 1971), and McCarthy, Robinson, and Brand (1985) found that large round baler technology reduced injuries when compared to stacker and square bale technologies.

Research in agricultural product safety engineering does not seem to be a priority with any public sector in the United States. Safety engineering is not a priority within the Agricultural Research Service (ARS), the major research branch of the United States Department of Agriculture (USDA). For example, there is no hint of safety engineering as an important area of research in the Research Agenda for the 1990s report by the Experiment Station Committee on Organization and Policy (ESCOP, 1990), nor in the National Association of State Universities and Land-Grant Colleges (1990) report Strategic Investments for Agricultural Research, Extension and Higher Education. Agricultural Engineering departments at land grant universities do not appear to be actively involved in product safety engineering. Most year end summaries of research projects list few, if any, projects involving machinery safety engineering. The lack of an aggressive and visible safety engineering research program to reduce agricultural machinery hazards appears to be a major stumbling block in reducing the level of risk associated with farm machinery and equipment.

Safety Legislation

In general there is little safety legislation that directly impacts the level of risk in the farm work environment, or on the safety behavior of farm workers. The exception to this statement may be chemical safety laws. However, chemicals, namely pesticides, are identified in relatively few cases of serious, acute trauma in any given year (Litovitz, 1988)

On the other hand, tractors, field machinery, farmstead equipment, farm structures, and farm animals are associated with the large majority of farm work fatalities and other serious injury (National Safety Council, 1991). Two pieces of safety legislation are in effect that address these risks. One of these is the Hazardous Occupations Training Order which identifies certain activities in agriculture as hazardous, and limits the employment of youth below the age of 16 in these activities unless they receive safety training. High school vocational agricultural programs and state Cooperative Extension Services are authorized to carry out the training programs, and many such programs do exist throughout the country. However, there is no known enforcement of the rules by U.S. Department of Labor, no farm employer has ever been known to be cited for failure to comply with the rules, and the rules are not applicable to family farms. The only published studies on the effectiveness of this safety legislation are by Silhetto (1976) and Williams (1983) which were reviewed earlier.

The other law impacting upon the level of risk in the farm work environment is OSHA (Occupational Safety & Health Act). OSHA is applicable in workplaces where an employer-employee relationship exists. From its inception in 1971, its rules and regulations were not applicable on family farms, the predominant type of farming enterprise. In 1976, Congress further reduced OSHA's ability to impact the agricultural workplace by restricting expenditures of funds to those farming operations that had over 10 employees. This effectively removed 97% of the agricultural operations from active OSHA rules enforcement. Still, approximately 45% of all agricultural workers were under OSHA jurisdiction. The apparent discrepancy in numbers is due to the large numbers of migrant and seasonal workers in temporary labor camps. These figures were provided by OSHA's Office of Statistical Studies & Analyses during appropriation hearings for 1977. Despite the large number of workers still under OSHA jurisdiction, OSHA rules and regulations did not greatly impact the risks or hazards associated with farming. The reasons for this are explained below.

Four agricultural standards were included with passage of the original act in 1971. These standards had to do with temporary labor camps, anhydrous ammonia, pulpwood logging, and safety signs and tags (Federal Register, 1971). The labor camp standard addressed issues of sanitation and housing for migrant workers and therefore had no impact on the level of risk associated with tractor, machinery, ladders, etc. Despite the implication, pulpwood logging is not considered a part of the agricultural industry (U.S. Office of Management and Budget, 1987), therefore this standard does not deal with injury issues for farmers. The anhydrous ammonia standard was largely applicable to the designers of storage and application equipment, and anhydrous ammonia dealers and suppliers. Only a few provisions of the standard were directed at on-farm handling and application. The safety signs and tags standard included requirements for the slow moving vehicle emblem and essentially adopted the provisions of ASAE Standard R276, approved by ASAE in 1967.

No evaluation studies on the effectiveness of these agricultural standards were found in the literature. The effectiveness of the slow moving vehicle emblem was mentioned earlier. By including this standard in the OSHA regulations and adopted by many states as part of their vehicle code, it is reasonable to conclude that the risk of injury to farm machinery operators on public roads was reduced to some extent. With this one exception, the impact on the level of risk to farm workers from these initial standards would seem to be negligible.

In the mid 1970s OSHA adopted two additional standards that were expected to have a large impact on agricultural workers. These standards were Code of Federal Regulations (CFR) no. 1928.51 Agricultural Tractors, Rollover Protective Structures, adopted in 1975, and CFR no. 1928.57 Guarding of Farm Field Equipment, Farmstead Equipment, and Cotton Gins, adopted in 1976. As previously stated, the majority of farmwork accident fatalities and serious injuries are tractor and machinery related. The benefits of these two standards would be realized by anyone who worked with tractors and machinery because the standards were largely directed at machinery manufacturers, rather than farm employers and employees.

Because the OSHA appropriations limitation, more commonly known as the small farm exemption, was implemented during the same time period, the effectiveness of the two CFR 1928 standards were severely compromised. This is particularly true of the rollover protective structures (ROPS) standard. Manufacturers continued (ROPS had been available as optional equipment for most tractors since 1968) to allow farm operators the choice of purchasing tractors with or without ROPS. With no tangible incentives for most farmers to purchase ROPS protection, the vast majority declined to do so. Coupled with the longevity of many tractors on the farm, this decision by manufacturers and farmers has been a major contributing factor resulting in less than 30% of all tractors on farms today with ROPS protection (Etherton and Myers, 1990).

The machinery guarding standard has potentially had a more positive impact on reducing risk in the agricultural workplace as guarding of hazardous machinery components has been much more commonplace than equipping tractors with

ROPS. However, as noted in the engineering discussion above, many guards are eventually removed once the machine reaches the workplace. With no enforcement of guarding standards by OSHA or other types of inducement, there is little incentive for farmers to keep machinery properly guarded.

Regulating safety in agriculture for the most part lacks political support among farm organizations who represent farm operators and owners. Farm worker organizations generally support stronger regulations. However, OSHA regulations can only be enforced on farming operations who employ 11 or more workers . The lack of political support for safety regulations among farm operators and owners, coupled with the significant cost to effectively enforce regulations on farms makes it extremely unlikely in the near future that regulations will be an effective measure in minimizing injury risk on farms.

Other Hazardous Industries

The mining and construction industry in recent years have experienced similar or significantly lower injury and death rates than agriculture. In 1990 the National Safety Council, reported that production agriculture experienced 40 deaths per 100,000 workers. This was 7% less than the rate reported for the mining industry, which experienced 43 deaths per 100,000 workers. The agricultural rate was 20% greater than the rate reported for the construction industry, which experienced 32 deaths per 100,000 workers. The injury and illness incidence rates, which is the number of loss work day cases per 100 workers, for agriculture was 59% greater than the rate for coal mine workers and 8% higher than the construction industry rate (National Safety Council, 1991). The injury and illness incidence rate was 3.6 for agriculture, 1.46 for mining and 3.32 for construction. The socially accepted means to address the accident problems in these two industries is substantially different from agriculture. Let's briefly review some of these differences.

One of the major differences is that the coal mining and construction industries have a comprehensive set of safety regulations. The mining industry has the longest history of government involvement of any U.S. industry (Hutchison, 1973). The Bureau of Mines was established in 1910 for the purpose of providing research and advisory inspections. In 1941 a law was promulgated that empowered federal investigators to enter mines uninvited. The first code of regulations was enacted in 1947 but with no provisions for enforcement. In 1952 a law was passed by Congress that provided federal inspectors with the authority to issue notices of violations and to order withdrawal of workers from areas that were deemed particularly hazardous. Mines with fewer than 15 employees, which were frequently found to be the most hazardous, and surface mines were exempted from the act. This exemption was removed in 1966 after strong labor union contention that the exemption was discriminatory towards employees who work in small mining operations. It is interesting to note the similar situation with production agriculture when the small farmer exemption was passed in 1976. That amendment is still in effect today.

As reported in *Injuries* (Robertson, 1983), in December of 1969 the Federal Coal Mine Health and Safety Act was signed into law by President Richard M. Nixon. This law was enacted to protect the health and safety of those who work in underground coal mines. The act covers both the health of the miner and the safety hazards associated with the mining environment. Responsibility for enforcing the act was assigned to two Federal Departments. These were the Department of the Interior, due to its long-time concern for mining concerns, and the Department of Health, Education and Welfare (HEW) because of its responsibilities and expertise in health protection. In 1977, the responsibilities for this act was transferred to the Department of Labor and the new agency was renamed the Mine Safety and Health Administration (MSHA). Additionally, an amendment was passed to the act that required that a minimum of two inspections per mine be conducted each year. The act also provides for the establishment of a National Advisory Committee on Coal Mine Safety and Health Research that is appointed by the Assistant Secretary of MSHA. The advisory committee consist of experts who represent workers, employers and government.

There is also a set of international standards that provide guidance to safety and health issues in mining. In April 1985, the International Labor Organization sponsored a meeting of mine safety experts for the purpose of developing an international code of practice on safety and health in coal mines (International Labor Office, 1987). This code of practice is essentially a voluntary mine safety and health work standard for both the public and private sectors who have responsibility for safety and health in coal mines. The code was developed with the objective in mind that it would provide guidance to those who may be involved in the development of standards or other regulations throughout the world. The code was developed by a group of experts who represented governments, employers groups and worker or employee groups. This code of practice set minimum safe work practices that should be required in mines throughout the world as agreed upon by workers, managers and government officials. As stated under the general duties of the code "In every country where coal is mined, it should be the duty of the government to enact sufficient appropriate legislation to ensure the safe conduct of the mines together with the minimum risk to health. Such legislation should be determined after.consultation with the most representative organizations of employers and workers. "The general duties of this code of ethics further states that the legislation should be enforced by the government and adequate financial support should be provided to adequately support the enforcement measures." Thus, there is a concerted effort of all major entities involved in coal mining playing an equal part in the development and promulgation of safety and health standards. Further, they have realized that for regulations to have an impact on reducing injury and illness rates they must be effectively enforced.

The construction industry possesses many occupational safety and health similarities to the agricultural production industry. As with agriculture, the construction industry is characterized by a high proportion of small firms. The financial resources of small firms is generally significantly limited. Thus, this often puts pressure on limiting the resources devoted to reducing the occupational injury and illness risk within their operations. As small operations they are unable to employ the services of safety professionals to provide training and site safety inspections to assist in reducing accident risk. Workers are often expected to perform a variety of tasks which make it difficult to maintain a strong consciousness of the safety procedures that should be followed for all tasks.

Construction workers work in a variety of conditions which are rarely similar because of the significant differences in the projects that they may be involved with. These workers, as with agricultural workers, often work under a variety of environmental conditions. They may be exposed to extreme temperatures, work around uneven work surfaces, exposed to high noise levels, and are often attempting to compete with seasonal weather changes in completing major projects. A high percentage of the work force are seasonal workers and do not maintain employment for long periods of time with the same employer, which is very similar to employees of farm operators. One major difference is that a high percentage of the work force in the construction industry are unionized, where as, a very small percentage of farm workers belong to a union (International Labor Office, 1987).

Federal occupational safety and health standards have been prominent in the construction industry for the past 20 years. Congress enacted the Construction Safety Act in 1969 which authorized the Secretary of Labor to establish safety standards for the construction industry. In 1971 when the Occupational Safety and Health Act was enacted by congress the standards that were developed under the Construction Safety Act were adopted by OSHA. Due to the limited resources that OSHA has for inspections of work places, it targets much of it's inspection efforts to high accident risk industries. Thus, typically approximately fifty percent of its inspection efforts are targeted toward the construction industry. Considering that there is an average of 420,000 constructions sites in the United States each year it is estimated that only about 8% of the sites are inspected each year by OSHA (International Labor Office, 1987).

One major form of behavioral control in reducing occupational injuries and illnesses is through the promulgation and effective enforcement of standards. The mining and construction industry believe that this is one of the primary means of motivating employees and employers to practice safe work habits. If standards or regulations are to be effective they must be generally accepted by the workers and employers of an industry. Another major ingredient for their success in reducing accident risk is that they must be effectively enforced.

Agricultural work activities are conducted under conditions providing little means of supervision or effective enforcement. This is one of the primary reasons why to date there has been no concerted effort to promulgate safety and health standards for work practices in production agriculture. There was an attempt when the Occupational Safety and Health Act was enacted in the early 1970s to include agriculture. But within a few years it was evident that this law was not generally acceptable to farm employers in this country and the small farm exemption act was passed.

Summary

There is over-whelming historical evidence that education as a primary means of injury control has been quite limited in its ability to significantly reduce injuries or the damage injury events inflict on individuals and society. Conversely, there is considerable evidence to indicate that engineering and legislatively oriented interventions have significantly contributed to injury control. These statements are true for a wide array of industries, industrial and consumer products, and groups of people. However, the seemingly logical conclusion that educationally oriented approaches to injury control should be dismissed is both theoretically and pragmatically unsound.

In the past, most educationally oriented programs have assumed that knowledge and an expression of safe attitudes would automatically alter behavior. This assumption has little support.

Another problem is that, historically, assessment and evaluation of injury control strategies have consisted primarily of population-based methods in agriculture. Population-based methods and the data generated are not always sensitive enough to detect the type of individual or small group behavioral changes that are of interest in agricultural safety. Nor does the data from these studies always provide the information necessary for optimal educational intervention.

In those instances where political and socio economic factors preclude or severely limit engineering and legislatively oriented safety interventions, the educational approach must be used. This is the situation that currently exists with agricultural safety. There are numerous practical limitations with the application of passive engineering and legislatively oriented safety interventions. It is universally accepted that passive engineering intervention strategies that do not require repeated effort to maintain, and are distributed population-wide, are inevitably going to produce superior outcomes when compared to behavioral methods. It is equally important to recognize, that we should not stop trying to improve educational methods while working to overcome political and socioeconomic barriers that prevent adoption of optimal injury control strategies.

Chapter IV
Behavioral Approaches to Modifying Safety Behavior

This chapter describes several contemporary theories relating to behavioral analysis, prediction, and modification. This includes a discussion of early psychological theories of behavior and their limitations. The primary focus of this section is on theories that have evolved over the last 15 years that have application for modifying safety behaviors of farm workers.

Early Psychological Theory

Classical Conditioning

Classical conditioning theory is one of the earliest empirically validated theories in psychology. The basic premise of classical conditioning is that an initially neutral stimulus will become endowed with positive or negative properties through repeated association with other stimuli that are inherently positive or negative (Pavlov, 1927).

To illustrate, imagine that a person typically eats their lunch at 11:30 A.M. Immediately before eating their meal (unconditioned stimulus) they begin to salivate (unconditioned response). This response is natural for animals and humans. Furthermore, immediately before eating, the individual hears a lunch bell ring. Over many lunch episodes, the ringing of the bell becomes associated with the food. Later, if the person eats lunch and hears the bell but does not receive their food, they are still likely to salivate (conditioned response). Remember, there is no food; they are salivating because of the bell (which is now the conditioned stimulus).

Hedonistic Principles in Psychology

Classical conditioning does not address subjective states (e.g., people's thoughts and feelings). "Hedonism" conceptualizations, in contrast, do address this. Bentham (1879) pioneered hedonism formulations by postulating the "hedonistic calculus." It states that people will act in ways that maximize their pleasure and minimize their pain. For example, if a farmer likes driving his tractor with the cab windows open better than with them closed, he will likely drive with the windows open.

Thorndike (1898) formalized hedonistic principles in psychology through the "law of effect." This law states that people are more likely to perform behaviors that consistently produce pleasurable consequences than behaviors that have the tendency to lead to painful consequences. Therefore, the "effect" of an action may serve as the cause of future behavior.

For example, imagine that a farmer has been injured several times handling dairy animals while not using any type of restraining equipment. However, he has never been injured while using adequate restraining equipment when handling dairy animals. Therefore, he realizes that using restraining equipment on animals significantly lessens the number of times he is hurt, thus, the more likely he is to use restraining equipment.

Operant Conditioning

Operant conditioning is defined by Skinner (1938) as associative learning that occurs when a response becomes more (or less) likely because of its positive (or negative) consequences. Operant conditioning is based on the assumption that people act to maximize the positive and minimize the negative consequences of their behavior. In other words, people tend to perform behaviors that yield rewards and to reject behaviors that result in punishment.

Operant conditioning can involve both positive and negative reinforcement. Positive reinforcement occurs when a pleasant event follows an action, such as when a child is given candy for helping his mother. Negative reinforcement occurs when something unpleasant is removed after performing an act. As an example, a farm worker who has in the past experienced a skin reaction on their hands when handling certain pesticides puts chemical gloves on their hands while working with these same pesticides that result in no skin reaction. The behavior that produced the relief of the discomfort is reinforced, so there is a tendency for that behavior to be repeated (e.g., put gloves on while working with pesticides).

Punishment is also a form of operant conditioning. Punishment is any event that follows a response and decreases the likelihood of that event occurring again. There are two types of punishment. The first is the presentation of an aversive event following an act. A motorist receiving a traffic ticket for speeding is one example. The second type of punishment occurs when a positive event is removed following an act. For example, a farm manager may tell their employee that he or she will not receive a financial bonus in their pay check if they observe the employee not wearing chemical personal protective equipment when mixing pesticides.

Is punishment effective? Clearly, punishment can stop a behavior. However, behavior suppressed by mild punishment will likely reappear later (Skinner, 1953). There are other side- effects to punishment. First, because punishment is usually painful or uncomfortable, people and/or situations associated with the punishment tend to become associated with aversion.

For example, the farm worker in the above example will likely dislike the farm manager. Moreover, punishment may encourage avoidance behavior (e.g., the farm worker may try to avoid the farm manager), and maybe even aggression. More research is needed on the role of punishment as a tool for safety intervention.

Skinner conceptualizes that because behavior is a function of automatic responses to positive or negative consequences, thought processes are unneeded to understand behavior. However, research shows that cognitive variables (e.g., intentions) do indeed augment a researcher's ability to understand and predict behavior (Fishbein and Ajzen, 1975; Locke, 1990). Cognitive psychologists recognize people's ability to reason, think, problem solve, choose among alternatives, and to impose their "free will" upon life's events.

Early Attitudinal Attempts at Behavioral Prediction

While behaviorists were examining specific stimuli that influenced behavior, many social psychologists were interested in how attitudes influenced behavior. An attitude is typically defined as a person's evaluative reaction toward some object. For example, if a farm operator says he "dislikes" regulations, he can be assumed to have a negative attitude toward regulations.

Thurstone (1929), Likert (1932), and Osgood et al. (1957) have developed measures of attitude. These measures often correlate highly when used together, thus suggesting attitude's construct validity.

Many early studies found very low correlations between attitudes and behavior (see Fishbein and Ajzen, 1975, for a review of this literature). Attitude measures did not predict behavior well in those studies because the measures did not correspond with behavioral criterions. For instance, consider the behavior of purchasing a rollover protective structure (ROPS). Hypothetically, researchers in the past may have analyzed the attitude-behavior relationship in the following manner. They would have asked farmers general attitudinal questions about rollover protective structures. Consider the following example where a farmer evaluates a set of three different adjective pairs that when summated provide a general evaluation of the farmer's attitude toward the behavioral statement. The farmer places an "X" on a seven point scale for each adjective pair as it reflects his feeling toward the statement.

"Rollover protective structures are"

wise	X	–	–	–	–	–	–	foolish
	+3	+2	+1	0	-1	-2	-3	
good	X	–	–	–	–	–	–	bad
	+3	+2	+1	0	-1	-2	-3	
pleasant	–	–	–	X	–	–	–	unpleasant
	+3	+2	+1	0	-1	-2	-3	

One way to calculate a farmer's attitude score is to sum across the adjective pairs. For this example, this farmer's attitude score toward rollover protective structures is: (+3)+(+3)+(+0)=9. This attitude score, however, may not be the same as his attitude toward "buying rollover protective structures". He may think that buying ROPS is foolish (-3), slightly bad (-2), and very unpleasant (-3). He would, therefore, have a very negative attitude toward buying a ROPS (i.e., -8).

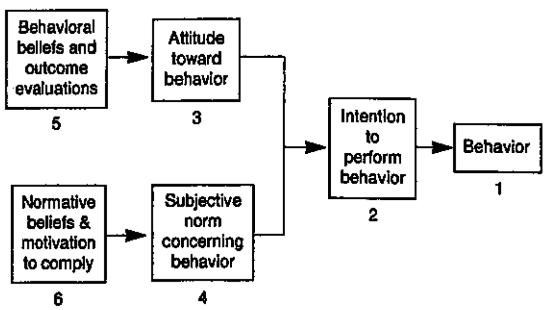
How is the "behavior" measured in many of these attitude-behavior studies? The simplest technique is to ask farmers if they performed the behavior. Past research indicates that these self-reports are usually quite accurate (Ajzen and Fishbein, 1980). Questions high in social desirability may present problèms, however. For example, if a researcher asked a farmer whether he or she polluted a stream on their farm last year as a result of their chemical applications, the farmer may distort the truth. If one is concerned about social desirability, there are techniques available that try to reduce this problem (See Cook and Campbell, 1979).

The discussion will now focus on contemporary behavioral theories that try to understand and predict behavior above and beyond attitudinal approaches.

Contemporary Theories of Behavior

Theory of Reasoned Action

Diagram 1: The theory of reasoned action



Intentions, Attitudes, and Subjective Norms. Fishbein and Ajzen's (1975) theory of reasoned action is a model of behavior that tries to both predict and understand behavior. Additionally, it provides strategies for behavior change. Most studies support the theory. (Sheppard et al., 1988).

The theory of reasoned action predicts behavior (box number 1 in diagram 1) by asking individuals whether they intend to perform a specific behavior (box number 2). "Intention", in turn, is determined by two components: attitude and subjective norm (boxes 3 and 4, respectively). The attitude component examines a person's attitude toward the behavior, while the subjective norm component examines the amount of pressure a person feels from significant others to perform the behavior. Both of these components are predicted by qualitatively different beliefs (boxes 5 and 6, respectively). We will now elaborate on each of these components in detail.

The theory of reasoned action's best predictor of behavior is a person's intention to perform the behavior. The model's components must correspond in terms of action, target, context, and time. If one aspired to predict whether a farmer would allow extra-riders on his or her tractor every time they operate their tractor within the next year, researchers would have the farmer respond to the following question:

"I intend to keep extra-riders off my tractor every time I operate my tractor within the next year."

likely – – – – – – – – unlikely

One year later, the researcher would ask the farmer whether they kept extra-riders off their tractor every time they operated their tractor in the last year.

If the goal is to change behavior, it is crucial that a high correlation exists between intention and behavior. If there is no relationship between people's intentions and actions, then any attempt to change behavior through intention will fail, because Fishbein and Ajzen's theory attempts to change behavior by altering people's intentions.

The attitudinal component is measured by the semantic differential using a series of bi-polar adjectives as illustrated earlier. The subjective norm taps the amount of social pressure a person feels to perform the behavior. Fishbein and Ajzen argue that people sometimes perform acts for which they do not have a positive attitude; they perform the behavior because of perceived social pressure. For example, a farmer that never wears his respirator while working alone may wear it when his wife is near by because she wants him to wear it.

Consider the following question which illustrates how the theory of reasoned action measures the subjective norm component.

"Most people who are important to me think

I should – – – – – – – – should not

keep extra-riders off my tractor every time I operate my tractor within the next year.

The attitude and subjective norm components together predict people's intentions. Multiple regression analysis shows the degree to which each of the components predict intention. Underlying these two components lie behavioral beliefs and normative beliefs.

Behavioral Beliefs. What are behavioral beliefs? How are they calculated and what is their significance to behavioral change? Salient behavioral beliefs are assumed to determine a person's attitude. Behavioral beliefs are also an indirect measure of attitude. Applying the theory of reasoned action requires the experimenter to ask subjects in a pilot study what they believe are the advantages and disadvantages of performing the behavior of interest.

After this, the experimenter looks for the most common stated beliefs. The common beliefs are then used to develop a closed-ended questionnaire. This process will be described shortly. The closed-ended questionnaire would then be distributed to a large sample of people. Please refer to Ajzen and Fishbein (1980) for technical applications.

The following beliefs are from an investigation using dairy farmers in Wisconsin (Aherin, 1987) examining extra-rider behavior. These were gathered in the initial pilot study. Farmers state that:

(1) not having extra-riders on tractors reduces the risk of a rider falling off a tractor and being run over.
(2) not having extra-riders on tractors reduces distraction to the tractor operator.
(3) having extra-riders on tractors helps when operating a tractor to hook and unhook wagons, watch machines, and open and shut gates.
(4) not having extra-riders on tractors wouldn't let others learn how to operate a tractor.

For the second stage of the study, closed-ended questions were derived from the first three beliefs because they were most common. Closed-ended questions probe two issues for each belief: belief strength and evaluation. Let us examine how the first belief in the above example would be translated into two closed-ended questions. The first closed-ended questions probes belief strength:

"Keeping all extra-riders off my tractor whenever I operate my tractor within the next year reduces the risk of a rider falling off the tractor and being run over."

likely	–	X	–	–	–	–	–	unlikely
	+3	+2	+1	0	-1	–2	–3	

The "X" above depicts how much a farmer believes this statement (i.e., +2). The second closed-ended question probes evaluation:

"Reducing the risk of a rider falling off a tractor and being run over is"

good	X	–	–	–	–	–	–	bad
	+3	+2	+1	0	-1	–2	–3	

The "X" above depicts how much the farmer values this belief. The values for the above two questions (i.e., +3 and +2) are then multiplied together (i.e., 3x2=6). This value represents the motivational impact this one belief has on the farmer's attitude toward allowing extra-riders on their tractor every time they operate their tractor within the next year.

These closed-ended questions are formed for each of the common beliefs selected. The process of combining one farmer's belief component score is detailed in table 1.

Table 1. An example of a farmer's overall belief component score

Beliefs	Outcome Evaluation	Belief Strength	Product
1. Reduces the risk of a rider falling off a tractor and being run over.	+3	+2	+6
2. Reduces distraction to the tractor operator.	+2	+2	+4
3. Having the help when operating a tractor to hook and unhook wagons, watch machines, and open and shut gates.	+1	–3	–3
4. Children wouldn't learn to operate a tractor.	–2	+2	–4
TOTAL (Sum)			+3

The farmer's overall score in table 1 is +3. This score would be correlated with the subject's attitude score.

This number is also an indirect estimate of the person's attitude toward the behavior.

Normative Beliefs. Recall that the subjective norm taps the amount of social pressure a person feels to perform a behavior of interest. This factor may be especially important in farm safety. For example, farmers' wives are usually very concerned about their husbands' safety, and some may try to influence their husbands' safety behavior.

The theory of reasoned action explains the subjective norm through normative beliefs and motivation to comply. Normative beliefs are analogous to the subjective norm except they look at specific individuals or groups rather than a combined generalization of all the groups and individuals. Normative belief information is collected during the pilot study by asking the respondent to list all individuals and/or groups who would have an opinion as to whether or not they should perform the behavior being evaluated. The researcher then identifies the most common normative beliefs stated by those in the sample. Typical significant others for farmers are their wives, children, co-workers, extension advisors, and farm organizations. The following question illustrates how the normative belief is measured:

My wife thinks that I

should	X	–	–	–	–	–	–	should not
	+3	+2	+1	0	–1	–2	–3	

keep all extra-riders off my tractor whenever I operate my tractor within the next year."

The following question illustrates how the motivation to comply concept is measured:

"Generally speaking, I want to do what my wife thinks I should do."

likely	–	–	–	–	–	–	X	unlikely
	+6	+5	+4	+3	+2	+1	0	

The normative belief and motivation to comply questions are combined by multiplying the two values together. In the above example: 3x0=0. Even though this farmer knows that his wife thinks he should keep extra-riders off the tractor, the influence of her thoughts on his behavior is zero. The products for each referent are summed for each subject to form their overall normative belief score.

Behavioral Change. The theory of reasoned action attempts to change behavior by changing intentions. To change intentions, one must change behavioral beliefs. Generally speaking, one tries to persuade people not intending to perform the behavior to think like people intending to perform the behavior.

Imagine that farmers not intending to wear respirators find them significantly more uncomfortable than farmers intending to wear them. Furthermore, imagine that this is the only belief that discriminated between the two groups. With this information, someone trying to get farmers to wear respirators would try to get the non-intending farmers to change this belief.

This might be accomplished by changing the respirator design to make it more comfortable. Here, psychological theory could provide engineers with valuable information for equipment modification. However, if the intenders and non-intenders did not differ on this belief, then no equipment modifications to improve comfort would be needed. Another approach would be to provide persuasive arguments such as the argument that preventing respiratory illnesses and the protection of their health is of a greater value in their decision to wear a respirator as opposed to their concerns about short-term comfort.

To summarize, the theory of reasoned action and related cognitive theories of behavior (e.g., Ajzen, 1985; Ajzen, 1991) are advantageous because they provide specific targets for belief change. Many "general" approaches to behavioral change (e.g., conditioning, Maslowian, and Freudian approaches) do not provide such precision for change. Although the theory of reasoned action has robust correlational support, the model needs more rigorous testing in the domain of behavioral change.

Social Cognitive Theory

Bandura's social cognitive theory (1977) assumes that people make causal contribution to their own motivation and action. The theory is very complex and rich. For purposes of this discussion, the focus will be on several aspects of social cognitive theory that seem most germane to safety applications. Refer to Bandura (1991) for a richer understanding of his complex theory.

Incentive and motivational processes are an important aspect governing peoples behavior in Bandura's social cognitive theory. There are three types of incentive processes in Bandura's framework. The first are direct incentive motivators: people will adopt modeled strategies if they result in valued outcomes. The second are vicarious incentive motivators: people are motivated by the successes of others who are similar to themselves, but not motivated when other's behavior is seen as leading to adverse consequences. The third are personal standard motivators: people do what they find self-satisfying and reject what they disapprove.

According to Bandura, virtually all learning can occur vicariously by observing other people's behavior and the consequences of the observed persons actions. An example would be a farm boy who observes on various occasions his father stepping over a revolving power take off shaft. Because the young man never observes a negative result of the action (i.e., entanglement in the pto) and the father is viewed as a credible source there is a good probability that the young worker will also perform this behavior when working around ptos.

According to Bandura, behavior is governed by several components operating together. Of the different components, self-efficacy beliefs play the central role in the regulation of behavior in social cognitive theory. Self-efficacy is a person's belief in their capabilities to mobilize the motivation, cognitive resources and courses of action needed to exercise control over events in their lives. In other words, a person with self-efficacy toward an act is a person who knows they "can" do the act. Two people with the same skills may perform very differently if they possess different self-efficacy beliefs.

There are four basic ways to strengthen self-efficacy beliefs: behavioral participation, modeling, social persuasion and realistic encouragements. The behavioral participation technique has people succeed at the behavior they are attempting. Basically, people come to believe that they can perform a behavior in the future because they have performed it in the past. Bandura claims that this is the most effective way to increase self-efficacy. Nonetheless, some performance behaviors may help people develop perseverance. Thus for some safety behaviors, it may be valuable to have the targeted population perform the desired safety behavior. This may be of particular value when training new farm machinery operators.

Self-efficacy beliefs have various effects. First, self-efficacy beliefs can affect choice; people avoid activities that they perceive are beyond their capability. For example, people with high self-efficacy consider more alternatives when deciding on careers. Second, self-efficacy can determine the level of effort people will exert in an endeavor and how long they will persevere in the face of obstacles. Third, self-efficacy can affect how much stress and depression people experience in threatening situations. People with high self-efficacy do not become overly stressed. Fourth, the higher the self-efficacy, the higher the goals people set for themselves and the higher the commitment to achieving those goals. Fifth, high self-efficacy in problem solving capabilities can nurture efficient analytic thinking. Finally, people high in self-efficacy are hypothesized to visualize success scenarios that provide positive guides for performance (Bandura and Wood, 1989).

Bandura states, "By sticking it out through tough times, people emerge from adversity with a stronger sense of efficacy". Although self-efficacy is often times advantageous, there may be anomalies. It may be dangerous for farmers to have high self-efficacy in behaviors that are highly related to fatal accidents. Illusion of control can be especially disastrous for high risk behaviors (Langer, 1975). For example, a farmer may think that he or she can drive their non-ROPS equipped tractor up a very steep embankment. However, if this perception is incorrect and the slope is too sleep for travel, the tractor may overturn.

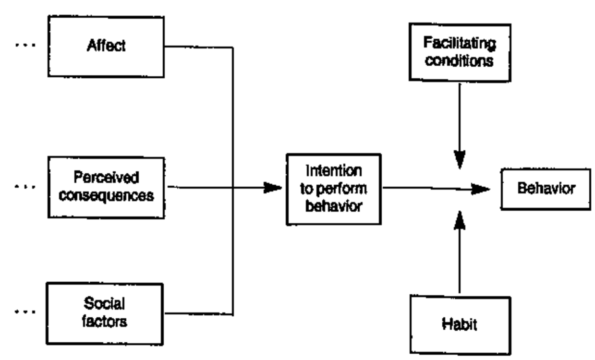
Bandura's self-efficacy concept and Fishbein and Ajzen's intention concept seem to be related in some situations. Fishbein and Ajzen suggest that people do not intend to do things they do not think they can do; therefore the self-efficacy construct is not included in the theory. Ajzen (1985, 1991) measures some aspects of self-efficacy in his theory of planned behavior, which is an extension of the Fishbein and Ajzen work.

Generally speaking, the theory of reasoned action and social cognitive theory seem to differ in terms of the behavioral domains of interest. Bandura and his associates tend to study behaviors or goals that people are striving for, whereas the theory of reasoned action tends to focus its analysis on predicting and understanding behaviors that are under a person's perceived control.

Theory of Interpersonal Behavior

Triandis's (1979) theory of interpersonal behavior, like Fishbein and Ajzen's, has intention as a determinant of behavior. However, Triandis also includes "habit" and "facilitating condition" constructs. The theory of interpersonal behavior (Triandis, 1979) and the theory of reasoned action differ primarily in terms of complexity. Triandis's model includes many predictor variables whereas Fishbein and Ajzen's model has only a few. See diagram 3 for a simplified overview of the theory of interpersonal behavior.

Diagram 3: The Theory of Interpersonal Behavior



Habit. Triandis defines habit as the number of times a person has carried out a behavior in the past. Triandis argues that people are habit-driven in many circumstances and that intention alone may not be the only behavioral determinant. For example, when people first learn how to operate complex machinery, much intentional thought goes into the activity. However, over time, the process becomes habit and conscious awareness of the process is not necessary.

Mittal (1987) tested the habit construct on seat-belt usage. He argued that intention may be a better predictor for low base rate behaviors (e.g., such as donating blood) whereas habit may be a better predictor for high base rate behaviors (e.g., wearing seat belts). Mittal defines habit as behavior occurring without awareness. He also makes a distinction between "use" and "nonuse habit." "Use habit" occurs when people perform a behavior without awareness. "Nonuse habit" occurs when people forget to perform a behavior. There is a potential problem with these habit definitions because questioning people about their "awareness" may make them think they were aware even though they may not have been. Mittal suggests that "due to the nature of the construct, an entirely satisfactory measure of habit may remain unavailable".

In summary, habit played a significant role in explaining behavior in Mittal's (1987) study. The "attitude-is-driving-the-behavior" model (such as Fishbein and Ajzen's) was not totally supported. That is, habit explained a significant amount of behavioral variance. The "habit-drives-behavior" model had some support; the more a behavior was performed, the more habit drove the behavior. Both constructs, therefore, seem to be necessary to understand behavior.

Habit seems to be an important variable in farm safety.

Reason and his colleagues have conducted a considerable amount of research on absent-minded errors where people carry out unintentional actions. They have found that most of the errors people make usually happen during routine, common tasks that seem to be carried out in a largely automatic fashion. Reason calls this "strong habit intrusion" and notes that the best probable way to prevent habitual errors is through the initial learning process of the behavior itself. This reinforces the importance of good safety training programs for new and younger workers. (Reason, 1976; Reason and Mycielska, 1982). It is better to teach the right safety habits initially rather than trying to change a learned undesirable habit later.

Facilitating Conditions. Facilitating conditions also influence behavior in the theory of interpersonal behavior. A behavior that is high in facilitating conditions is one that is relatively easy for a person to carry out. Farmers who desire to wear proper protective clothing but do not have any available are in a low facilitating conditions situation.

The theory of interpersonal behavior predicts intention from three factors: perceived consequences, affect, and social factors. Perceived consequences is the same as Fishbein and Ajzen's behavioral belief component. The affect component examines people's "gut" feelings or emotional reactions toward performing the act (and is related to classical conditioning principles). For example, a person may know that touching a snake will not harm them in any way (perceived consequences) yet still feel disgusted thinking about doing it.

While the theory of reasoned action has one social factor (i.e., the subjective norm), the theory of interpersonal behavior has several: norms, roles, and the self-concept. For further specifics on these components and conceptual differences between the theory of reasoned action and the theory of interpersonal behavior see chapters by Triandis and Fishbein in the 1980 Nebraska Symposium of Motivation.

Both the theory of reasoned action and the theory of interpersonal behavior have empirical support. Thus, farm safety specialists may utilize both when trying to understand why farmers may perform unsafe activities. The following cognitive theories in social and industrial psychology may also be useful: the theory of planned behavior (Ajzen, 1985; Ajzen, 1991), Naylor, Pritchard, and Ilgen's (1980) theory of organizational behavior, and Vroom's (1964) expectancy-valence theory.

Goal-Setting Theory

Locke's (1990) theory of goal-setting may also be relevant to farm safety issues, although it has been typically applied to increasing worker productivity. It states that people given specific/difficult goals on tasks outperform people given vague or do your best goals. Locke's theory is very robust, most experiments support it (Locke, 1990). There are a couple prerequisites for the theory to work. The goal should be accepted by the person, the person should get feedback from their performance, and the goal should not be impossible, although in some studies, even people with impossible goals outperform people with vague or do your best goals.

Bandura and his colleagues illustrate additional goal effects; goals build people's beliefs in their capabilities, provide standards to compare performance, and provide positive self-reactions when the attained outcome is close to the goal (Bandura and Cervone, 1983; Bandura and Wood, 1989).

Reber and Wallin (1984) illustrated the benefits of providing knowledge of results and goal-setting to improve occupational safety in a farm machinery manufacturing firm. They found significant main effects for each of the intervention strategies they employed: safety rule training, goal-setting, and knowledge of results. Felner and Sulzer-Azaroff (1984) have also shown the utility of clear feedback systems in industrial settings.

Behavioral Science Technology (Krause and Hidley, 1989) applies an observational feedback approach for industrial applications. This approach utilizes basic goal-setting techniques. Many of the corporations using these techniques have claimed considerable success. The approach stresses that employees cannot be punished for doing something wrong. Although this may seem imprudent if a person did something dangerous on some occasion, the principle has some psychological support; if coercion were used, one would find that over time, employees would conceal accidents and only act safely when the observer came into view. In the long run, noncoercion tends to pay off in industrial work places.

Goal-setting theory may be useful in corporately-owned farms where there is supervisory control over employees, but may have difficulties on traditional farms, because it is probably much more difficult to set safety goals for autonomous farmers. Who would evaluate the farmers, and why should the farmers embrace externally set goals? Although, this might be accomplished by providing farmers with adequate financial incentives or other strong positive stimulus. Nonetheless, if an educator gives a farmer a specific safety goal, the farmer should also be given convincing rationale for why he/she should be committed to the goal. (See Locke et al., 1988; Hollenbeck and Klein, 1987, for detailed discussions on goal commitment and goal acceptance.)

Judgment and Decision-Making

vonNeuman and Morgenstern (1947) and Savage (1954) have laid much of the ground work for contemporary decision theory. Decision theory attempts to predict and understand decision-making processes and outcomes. However, many farm accidents are due to improper decision-making that lead to dangerous behavior. Therefore, it is important to have a general understanding of this literature.

Heuristics and Biases

Kahneman and Tversky have provided considerable information about decision-making and natural reasoning. When making a decision, one's beliefs play a very important rol illustrated earlier. The degree to which we bel something is an important factor in decis making.

Assessing beliefs can be quite complex, Kahneman and Tversky (1982) illustrate people use a limited number of heuristic simplify tasks. Psychologists use the t "heuristics" to denote a general guideline arriving at a solution. That is, a rule of thu Heuristics can be quite useful, but can lea erroneous conclusions also.

In farm safety, behavioral outcome beliefs very important. Farmers often think that acts perform are safer than they actually are. In o words, they would estimate that the probabilit an accident occurring from the acts they engag is lower than what it is in reality. The typ heuristics people use to assess probabilitie discussed next.

Representativeness. People use representative heuristic to make a quick judgen about a probability by comparing the fac involved with an immediate decision with a sin example in memory. Consider the follow experiment. In one of the conditions, subjects told that a person had been picked at random f a sample of one hundred people, seventy of w were engineers and the remaining thirty lawy This was the "engineer-high" group. The o group was told that seventy of the people v lawyers and thirty were engineers. This was "engineer-low" condition. When subjects w asked to estimate the probability that a pe picked at random would be an engineer, subjec both groups were generally accurate. In the phase of the study, subjects were told that ano person had been picked at random from sample. But this time the following was given sketch of this person:

Jack is a 45-year-old man. He is married has four children. He is generally conservat careful, and ambitious. He shows no interes political and social issues and spends most of free time on his many hobbies, which include h carpentry, sailing, and mathematical puzz (Kahneman and Tversky, 1973).

Subjects in both groups ("engineer-hi probability and "engineer-low" probability) v then asked to estimate the probability that person in this description was an engineer. E though subjects had the same probabi information available about the percentag lawyers and engineers in the respective gro subjects weighted the descriptive information heavily with both groups estimating that there a 90% chance that Jack was an engineer. Kahneman and Tversky argue that this happened because the profile of Jack is more representative of an engineer than it is of a lawyer. The subjects used this information more heavily than the base rate information. That is, they did not take into consideration the actual probability of engineers and lawyers in the sample when evaluating their decision. Thus, people often underestimate injury risk because of past experiences.

People also have misconceptions of chance. The "gambler's fallacy" illustrates this representative bias. For example, after witnessing a coin landing heads-up 7 times in a row, most people falsely believe that a tails is due on the next flip. Of course, on the next flip of the coin, the likelihood of heads or tails is still 50/50. The representative heuristic can also explain "regression to the mean" phenomena. In many situations, the effect of punishment and reward are confounded by regression to the mean. To illustrate, rewards are typically given after good performance. People receiving rewards after good performances will tend to perform more poorly on their next performance independent of reward. So the reward may not seem effective. In contrast, after someone behaves incorrectly, punishment is often administered. These people would tend to behave more appropriately on a subsequent occasion, not because of the punishment, but simply due to the statistical regression effect. But if punishment were used, it would be given the credit. For example, imagine that a farm employee got a chemical burn because he or she did not wear their protective gloves. As a consequence the employer punished the employee. After this, the worker started to wear protective gear. The employer believes that their reprimand produced the effect, but the employee may have worn the protective equipment anyway, regardless of the employer's reprimand, in order to secure their safety in the future.

Farmers may erroneously use the representative heuristic when considering the probability that they will become involved in an accident. For example, a farmer may be told that there is a 30% chance that they will be involved in some type of farm accident within the next year based on accident survey data. However, because the farmer believes he or she is a "safe" farmer, the effect of the original information is less than optimal.

Availability. The availability heuristic occurs when people estimate probabilities as being higher for things that come readily to mind (Kahneman and Tversky, 1973). Consider an experiment conducted by Slovic, Fischoff, and Lichtenstein (1981) which examined how subjects estimated various occurrences. Subjects were asked to state which of the following occurrences were more likely: death as the result of all forms of accidents, strokes, homicides, diabetes, all forms of cancer, or heart disease. Most subjects falsely estimated that death was more likely from accidents, homicide, and cancer. Strokes, diabetes, and heart disease actually take more lives. The mass medias' coverage of accidents, homicide, and cancer seems to make these events more available in memory, thus influencing subjects' estimates.

Farmers may underestimate the occurrence of some farm injuries because they do not have information available on the topic. Or as Kahneman and Tversky (1982) state, "the risk involved in an undertaking may be grossly underestimated if some possible dangers are either difficult to conceive of, or simply do not come to mind". Therefore, education programs providing farmers with information about risks on the farm seem well advised.

Adjustment and Anchoring. Sometimes people use any information available to them to ease their judgements. The anchoring heuristic can be illustrated by the following example. Two groups of subjects estimated, within 5 seconds, a numerical expression that was written on the black board. One group estimated:

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$$

while another group estimated:

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$$

To answer these questions in five seconds takes some rough estimating. The anchoring and adjustment heuristic predicts that people anchor their estimates on initial information. In the first example above, subjects would start with 8×7, which would be a much larger initial value than 1×2. Subjects in the first group should have higher estimates than subjects in the second group. The median estimate for the first array of numbers was 2,250, whereas the median estimate for the second array was 512, thus supporting the anchoring and adjustment heuristic.

The anchoring and adjustment heuristic may also be relevant when people learn and model. For example, imagine that a child watches their parent perform an unsafe behavior. When the child is presented with a dangerous situation at some later point in time, the child may recall their parent's unsafe behavior and act similarly. The model, in effect, provides the available information for the anchor.

Overestimation. Traffic researchers (Brown, 1982; Svenson, 1978; Dawson and Everall, 1972) have shown that people grossly overestimate the amount of time they save by speeding. These faulty perceptions in turn may influence people's intentions to engage in dangerous activities, such as high speed passing. Farmers may also overestimate the amount of time they would save by performing dangerous activities.

Optimistic Bias. The optimistic bias often occurs when people say that they are less likely to be affected by some harmful agent than their peers (Weinstein, 1989). According to Weinstein, "optimism is greatest for hazards with which subjects have little personal experience, for hazards rated low in probability, and for hazards judged to be controllable by personal action" (p. 240). Optimistic biases can be especially problematic in farm safety because farmers may perceive that they are not at risk of an injury by performing a specific behavior while they perceive that other people are at risk of the same injury when performing the same behavior.

Risk Taking

Risk is a common component to everyday life. Walking across the street, driving a tractor, deciding on a financial investment, choice of professions, riding in an automobile, or getting married are all examples of potential risk of varying magnitudes. Risk is a certainty of life. Some people even seek risks. To set high goals of success, for example, is to run high risks of failure. Risk can be defined as "...to expose to the chance of injury or loss "(Fischhoff et al., 1981). There are three components of risk: the magnitude of loss, the chance of loss, and the exposure to loss. One must reduce at least one of these components to reduce riskiness. There are also three determinants of risk: when a person lacks control, has insufficient information, or has insufficient time.

While some people think risk taking is foolish, others find it a way of showing competence. For instance, a farmer may feel that driving on steep embankments without undue anxiety shows his or her competence. The farmer may actually have this skill, but there are two immediate problems in this example. First, something unexpected may occur, such as hitting a rock, which could result in the tractor overturning. Second, trainees may model and attempt this behavior even though they have not acquired the necessary skill yet.

Do people take preventative action when risks are made salient or conspicuous to them? Weinstein et al (1986) analyzed this question in a study of seat belt usage. They used various media techniques to make risks salient: stickers for car dashboards, permanent signs in the parking deck, and temporary signs in the cafeteria. They found a significant increase in seat belt usage after implementing these strategies. This study suggests that emphasizing risk susceptibility in training programs is effective. However, their study did not look at the effects of these treatments over time. It is unclear whether the effects would last. Similar experiments with farmers are greatly needed.

Decision-Making Under Stress

Working under stress can influence people's decision-making strategies. Psychological stress exceeding a certain intensity affects the quality of decision-making (Keinan, 1987). There tend to be three ways people make errors when stressed: decisions are reached before all available alternatives have been considered; alternatives are scanned in a nonsystematic, disorganized fashion, and not enough time is given to consider each alternative. An implication for farmers is to get them to scan and evaluate alternatives more carefully under time constraints.

Steffy et al. (1986) illustrate the impact of stress reduction programs on decreasing employee accidents. They propose a stress/accidents model linking stress to psychological, physiological, and behavioral impairment and increased accident risk. Stress reduction programs have yet to be evaluated with farm populations.

Models of Behavior Dealing Specifically with Risk and Danger

Health Belief Model

The health belief model was originally developed to understand people's reluctance to accept screening tests for the early detection of asymptomatic diseases. Several components comprise the health belief model: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers.

Perceived susceptibility "refers to one's subjective perception of the risk of contracting a condition" (Janz and Becker, 1984, pp. 2). Relating this concept to farm safety, this perception would be equivalent to a person asking the question "will I get hurt if I perform this act?". Perceived severity is the subjective perception of the seriousness of contracting the illness or condition. This would be equivalent to a person asking the question "how bad would I get hurt if I were to be injured?". Perceived benefits examines the feasibility and efficacy the person associates with performing the act. A farmer would have to feel that the safety act avoiding the danger would be a feasible act to perform. Perceived barriers are the possible negative aspects associated with performing the act. A farmer may not consider a safety act if there are barriers in the way of performing it (Janz and Becker, 1984).

The health belief model also discusses a "cues to action" concept. Janz and Becker (1984) argue that cues to action are needed to trigger the person to engage in the decision-making process. However, few studies have assessed the contribution of this concept. This concept seems especially meaningful for farm safety applications. For example, because many of the dangerous acts farmers engage in are done automatically, someone noting to a farmer that they should think about what they are about to do could trigger the necessary thought processes for the farmer to decide to not engage in the act on their own volition.

The health belief model has considerable empirical support. However, the model has not been applied to farm safety interventions, although it has been applied to driving safety. One limitation of the model is that "while the health belief model specifies relevant attitude and belief dimensions, it does not dictate any particular intervention strategy for altering those elements" (Janz and Becker, 1984, p. 45). Another limitation is that the components in the model have lacked refined and standardized tools of measurement. Nonetheless, the health belief model provides additional concepts for which to understand farm safety behavior.

Protection Motivation Theory and The Control of Danger Model

"... a basic postulate (of protection motivation theory) is that protection motivation arises from the cognitive appraisal of a depicted event as noxious and likely to occur, along with the belief that a recommended coping response can effectively prevent the occurrence of the aversive event" (p. 99, Beck, 1984; 1987). According to Beck, this model may also be used in a broader sense to help explain risky decisions. The model uses the following components to predict such decisions: (1) magnitude of noxious consequences, (2) probability of occurrence, (3) efficacy of the recommended response, and (4) self-efficacy. The theory is similar to the health belief model in that it analyzes specific belief structures. The theory is also related to the theory of reasoned action because it examines "protective decisions (intentions to act)". (pg. 121). The theory of reasoned action (Fishbein and Ajzen, 1975) and the theory of planned behavior (Ajzen, 1985) specifically look at intentions. Protection motivation theory relates to farm safety because it examines specific issues in the fear appeal-threat communication literature, from which it was derived. The effect of fear arousal on persuasion will be discussed later.

Hale and Glendon's (1987) control of danger model examines how people behave in the face of danger. Their model integrates a large amount of conceptual and empirical material in psychology. An attractive component of the model is the "level of functioning" conceptualization. This factor is similar to Triandis's habit/intention distinction. The model's dynamic nature, illustrated by feedback loops, is another attractive feature of the model.

The contemporary and emerging behavioral psychological theories and concepts related to analysis, prediction, and modification of behavior have the potential to positively effect injury control efforts in agriculture. This would be accomplished by providing a more definitive understanding of the safety behavioral issues associated with farm work. These theories and concepts can be utilized in developing a more complete understanding of the causative factors, identification of appropriate intervention methods, and as program evaluation tools for behaviors associated with farm safety issues. Agricultural safety professionals and those involved in agricultural safety research and education should familiarize themselves with these concepts and test them among farm populations.

Chapter V
Safety Communication

Persuasion

The theory of reasoned action suggests that attitudes toward behavior can influence behavior by changing a person's behavioral intention. Therefore, changing behavioral attitudes should be fundamental in changing farm worker behavior. Attitude change and persuasion is reviewed next.

The persuasion literature suggests a number of variables that may affect persuasive arguments, including: characteristics of learning, source characteristics, social support/conformity, personal involvement, fear arousal, and characteristics of the message itself.

Characteristics of Learning

Does simply learning a message change attitudes? Many studies show only a weak relationship between learning persuasive information and attitude change (Lichtenstein and Srull 1985; McGuire, 1985). For instance, farmers may be able to remember opinion loaded information, but will not accept it as being correct.

People can learn attitudes through simple transfer of affect (Lorge, 1936). For example, many advertisers have attractive men or women display their products. These attractive attributes may be transferred to the object. Classical conditioning principles are presumed to govern this process (Pavlov, 1927).

Cognitive consistency theories (Heider, 1958; Festinger, 1957) represent a more cognitive interpretation of attitude change. These theories argue that people are motivated to reduce inconsistency among cognitions because inconsistency is presumed to be uncomfortable. For example, if a person feels that wearing eye protection is negative and then hears positive information about eye protection, the person would be in a state of dissonance. The person has several ways to reduce the conflict. He or she can either change his or her perception about the validity of the information (e.g., "those people don't know what they're talking about"), or change his or her attitude.

The instructional method utilized can also affect the learners' ability to acquire and understand a message. Clark and Clark (1984) suggest that instructional methods match specific learner populations in order to maximize effectiveness. Instructional methods should be prescribed based on an analysis of the psychological demands of the learning task and the psychological characteristics of the learner population. They state that defining an effective instructional method is complex and involves three factors: 1) the psychological processing demands of a given task; 2) the role played by a particular instructional method to facilitate acquisition of the task for a given learner; 3) cognitive and motivational differences in learners and their effects on the interaction between the demands of the task and the instructional method.

Message Source Characteristics

Communicator expertise is one factor shown to have positive effects on attitude change (Aronson, Turner, and Carlsminth, 1963). Non-experts arguing for a position are not as effective as experts. Several studies have also shown that the more credible a source is perceived, the more persuasive their message (Aronson and Turner, 1963; Maddux and Rogers, 1980). However, there are some conditional expertise effects. Petty, Cacioppo, and Goldman (1981) found that if the message is highly relevant to the audience, the expertise of the source has little or no effect.

Wood and Eagly (1981) and Chaiken (1980) found that communicator's expertise did affect persuasion and, furthermore, the more credible the source, the less likely they were to be perceived as biased. For instance, using a source like the Secretary of Agriculture may be a powerful persuasive tool for several reasons. First, the Secretary of Agriculture possesses position power. Position power refers to "the right" of the leader to influence a subordinate and the obligation of a subordinate to accept that influence" (Landy and Becker, 1987). Second, because such a source is not affiliated with any manufacturer they would be perceived as unbiased. Due to the financial benefits the manufacturer gains by selling safety equipment persuasive material presented by manufacturers may be seen as biased. Regardless of the communicator, the expertise of the source must be established prior to the persuasive communication if their expertise is to have any effect.

The type of information presented in the communication also affects the persuasiveness of the source. For example, an expert source should be used to maximize persuasion if they are to present quantitative information. In contrast, if qualitative information is presented, the expertise of the source has little or no effect on persuasion. Using an expert source may not always result in more persuasion, but it will not decrease persuasion.

Heesacker, Petty and Cacioppo (1983) concluded that source credibility is related to message content processing. They have shown that increasing source-credibility enhances message-relevant thought, even for subjects who typically do not scrutinize message content. Therefore, the importance of using communicators who have high levels of expertise is again replicated.

Source attractiveness has also been investigated. Results suggest that attractiveness of the source is not as important in persuasion as expertise (Maddux and Rogers, 1980). However, when expertise of the source is not considered, and the persuasion is in the form of an emotional appeal, persuasion is best if the source is attractive. This may be because emotional messages are processed heuristically, whereas rational messages are processed systematically.

Communicator trustworthiness is another important source characteristic. Basically, the more the communicator is trusted, the more likely he or she will be able to change another person's attitude (Walster, Aronson, and Abrahams, 1966). Trustworthiness is usually deduced by attribution. For example, people can either decide that the communicator's statements are truthful or biased. In the process of persuasion, the communicator wants to make certain their audience perceives him or her as unbiased.

Likability is another relevant source characteristic. The more a person likes the communicator, the greater the likelihood the communicator can influence the person's attitude (Chaiken, 1979). Also, communicators tend to be liked more when they are similar to their audience. Therefore, similarity between communicator and audience is beneficial in trying to change attitudes (Brock, 1965). Good arguments in a persuasive message are much more important in an expert's message, but not as important for a lik nonexpert (Norman, 1976).

To sum, a potent communicator for agricultu safety would be a person that is an agricultu safety expert, who is trusted, liked, and ve similar to the farmers.

Social Support/Conformity

Life does not occur in a vacuum, and because daily interactions with others it seems likely tl people's attitudes are affected, in at least so degree, by the attitudes of those they meet. Stro and Diehl (1981) found that subjects complied m often with persuasive arguments under conditi where others also complied than under conditi where others did not comply. Moreover, th attitudes changed more under conditions compliance with an "attitudinally nonsimi other" rather than a "similar other".

Campbell, Tesser, and Fairey (1986) studied effects of self-esteem, pressure, and norms attitude change. They concluded that conformity persuasive arguments is greater with individu who have a high degree of self-doubt, hi pressure, extremity of the norm, and increas extremity order. The results also indicate tl pressure and self doubt interacted in affecting audience's attention to the stimulus such tl attention was low when both were absent, h when only one was present, and moderate wh both were present.

Personal Involvement

The degree to which individuals are involved the setting also affects the amount of attitu change. Zimbardo (1960) found that higl involved subjects changed significantly more tl subjects not involved in the issue. One way increase the involvement of farmers in the saf issue may be to develop and fund local task for to investigate the safety problem in their ar Based on findings such as these, any program t requires the direct participation of the farm could potentially increase persuasion and saf behavior.

Fear Arousal

In most circumstances, arousing fear increa the effectiveness of the persuasive communicat (Higbee, 1969). However, if the fear level in communication is too great, less change may res because of people's defense mechanisms agai the frightful information (Janis, 1967). So studies have shown that simple instructions about healthy behavior is more effective than arousing fear (Levanthal et al., 1965). There are other conditional effects of fear arousal. Piccolino (1966), for example, found that posters evoking high fear about the effects of falling down stairs worked well if they were placed directly by the stairs. People could immediately and simply respond to the fear by grabbing the rail.

What are effects of fear arousing stimuli over time? Pirani and Reynolds (1976) found that high fear arousing posters initially resulted in an 18% increase in protective equipment wearing. But the effects were short lived. After four months, the data regressed to an overall loss of 2%.

When a person is presented with information that suggests they are at high accident risk, the person may become frightened and act accordingly. The presentation of risk susceptibility information, instead of graphically frightening scenes, has the advantage of mitigating avoidance behavior. Weinstein's (1986) work, discussed earlier, illustrated the advantages of presenting risk susceptibility information. Research needs to be done in this area with farming populations.

Characteristics of the Message

There are several significant characteristics of the message that can effect persuasion. The amount of discrepancy between a communicator's position and the audience's initial position is an important consideration. The greater the discrepancy, the greater pressure to change one's attitude (Hovland and Pritzker, 1957). However, greater discrepancy works up to a certain point; beyond that point, the audience starts dismissing the source. For example, a communicator may present information advocating farmers to wear protective equipment in dangerous situations. Many farmers may accept this communication. But if the communicator advocates wearing protective gear all the time (a very discrepant view), farmers would probably ignore the source.

Research has shown that the more arguments an expert presents, the more persuasion takes place (Norman, 1976; Harkins and Petty, 1981; Maddux and Rogers, 1980; Cacioppo and Petty, 1979). However, strong arguments tend to change attitudes in some situations more than others. Petty and Cacioppo (1986) note that when people scrutinize the communication closely, strong arguments are indeed better than weak ones. When the issue is not very relevant to the audience, superficial communicator characteristics, such as source attractiveness and likability, should be more effective in changing attitudes.

The orientation, or style, of the persuasive message may also have an effect. Snyder and DeBono (1985) found that image-oriented advertisements were preferred by high-monitoring individuals while low-monitoring individuals preferred quality-oriented advertisements. Individuals expressed differential degrees of willingness to purchase the product based on the image-orientation. This type of information may be particularly helpful in designing safety campaign communications for various populations of farm workers (e.g., posters, flyers).

Even the method of introduction can have a powerful effect on persuasion. Introductions using rhetorical questions have been found to produce more positive attitudes than introductions with weak arguments. When involvement is low, rhetorical question introductions work well, but when involvement is high, less positive attitude change occurs.

Once a message is developed, does repetition matter? Cacioppo and Petty (1979) show that repetition increases attitude change to a point, but then starts to decline. For example, farmers may be responsive to a message they hear a few times, but not to a message they hear too much. To reduce the tedium, alternative versions of the same message can be introduced.

When an issue has little significance to a person, peripheral cues become more important in determining attitude change. Likability and credibility of the communicator would be considered important cues in this situation. Similarly, having other pleasant attributes in a communication, such as music, can be effective if the person has little motivation to think about the message. However, when people are motivated to listen to the message, the content of the communication is clearly more influential for attitude change (Gorn, 1982).

The Audience

The effect of persuasive communication also depends on the person to whom it is directed. Even the best communication may be ineffective if the receiving party is committed to their attitude. The strength of commitment is a function of several variables. One is the amount of behavior performed on the basis of an attitude. For example, the more a farmer does not wear protective eye equipment, the more likely the farmer will not do so in the future. This farmer would not be very receptive to pro-protective eye equipment information.

Commitment to an attitude is also influenced by public statements. If a farmer, for example, tells fellow farmers that "ROPS are for sissys," the farmer would be more committed to their attitude and less willing to change their attitude than another farmer who has not made the public statement.

People committed to their attitudes have several responses to counter rival messages. They can derogate the source or distort the message. For example, imagine that a farmer hears a persuasive message containing statistical arguments. The farmer may be convinced that the statistics are biased and therefore do not represent him. A person could also reject information altogether, even without reason (i.e, "blanket rejection"). Counter-arguing is another common response to discrepant communication. If a safety specialist uses fear as a tactic to change attitudes, farmers may simply turn away from the frightful information or convince themselves that they have control over those types of situations.

Research has been conducted testing the notion that some people are more susceptible to persuasive communication in various situations than others. This notion has some support (Hovland and Janis, 1959) but the effect is relatively weak. Evidence shows that people with low self-esteem tend to be more easily persuaded than people with high self-esteem. However, the idea that highly intelligent people are more resistant to persuasive communication than people less intelligent has not been generally supported. But the relationship between intelligence and attitude change may be more complex. For example, Eagly and Warren (1976) suggest that highly intelligent people are influenced less by illogical arguments than are people of lower intelligence.

Attitudes toward a behavioral act that change due to a persuasive message have been shown to weaken over time (Tesser and Shaffer, 1990). This is because specific details of the argument decay with time. In other words, a communicator may be able to persuade by argument, but the effect may wash out over time, unless the message is consistent with the person's long-standing values and cognitions. The attitude change may be held longer if the learner is exposed to the persuasive message at continual intervals.

Effectiveness of the Medium

Research comparing the learning effectiveness of different media has been inconclusive at best. Media comparison studies, despite their failure to provide any support for their position, have led some to believe that media is the solution to most instructional problems (Winn, 1984). Winn (1984) goes on to state, "this type of advocacy is indiscriminate and sometimes dishonest. At best, it betrays a lack of awareness of the most important issues that are preoccupying researchers and practitioners in our field at the present time".

The problem centers on the distinction between media, messages, and methods. Winn defines a medium as a device for getting information from one point to another. Hence, it cannot logically effect how people learn. Therefore, the question, "Which medium is best for effective learning?", is inherently flawed. Media serves as the delivery function, whereas methods and messages serve as instructional functions. Therefore, the logical question to ask is, "What methods and messages are best for effective learning?".

Clark and Clark (1984) present the most conclusive evidence that the choice of media, in and of itself, does not affect performance. Clark and Clark applied a meta-analysis to media research and concluded "media do not under any circumstances influence performance". This research supported Clark's (1983) earlier conclusion that "all training media are merely vehicles for delivering instruction that have no ultimate influence on the performance of those trained" (Clark, 1983). Clark and Clark concluded that different types of media can be equally as effective if the same instructional strategies are used. They also noted that newer media are erroneously classified as more effective merely because, for a short time, they are more interesting. Similarly, Gagliano (1988) found that video presentation was as good, or more effective, than traditional methods of patient education in increasing short-term knowledge, however it offered no advantage in improving long-term retention of knowledge or in promoting compliance with medical regimens. Moreover, Jamison, Suppes, and Wells (1974) found that in other than the most obvious cases, any medium will handle any subject matter content effectively.

Warnings

The apparent absence of technical guidelines defining what constitutes a legally adequate warning has plagued manufacturers for years. The definition of "legally adequate" centers on the issue that warnings must be designed such that "they would reasonably be expected to reach and be understood by the user" (Kammer v. Lamb-Grays Harbor Co., Inc., 1982). The question still remains as to which components of the warning produce maximal compliance. As the result of an extensive literature review, several issues will be reviewed.

The primary function of product safety communication is to prompt the product user to follow recommended safe work practices in the use of the product so as to minimize the potential risk of injury. The information presented must attempt to get the attention of the product user, motivate them to think about the recommended behavior and follow the recommended behavior or practice. Rogers (1975) found that to enhance attitude and behavioral change safety communication must contain three crucial components:

1. **The magnitude of noxiousness of the depicted event and personal relevancy of the event.**
   The product user must be made aware of the potential severity of injury or illness, if the recommended practices are not followed. Also, they must feel that the behavior is relevant to them.
2. **The probability of the events occurrence.**
   The person attending to the communication must feel that there is a strong likelihood that the injury or illness will occur to them, if the recommended behavioral practices are not followed. They must feel that either there is high probability that an injury or illness will occur and/or that the resulting injury or illness will be very severe.
3. **The efficacy of the protective response.**
   Information must be provided that will inform the user of how to practically and effectively avoid the risk.

The FMC corporation (Bennett, 1990) incorporated the above findings into their recommended guidelines for creating a message for product safety signs. They state that an effective message for a product safety sign must communicate the following:

1. The nature of the hazard.
2. The level of hazard seriousness.
3. How to avoid the hazard.
4. The consequences of human interaction with the hazard.

The nature of the hazard would be identified at the time that the need for the decal is identified. The level of the hazard seriousness is determined from the definitions of Danger, Warning, and Caution. The definitions presented here are taken from American National Standard Institute standard ANSI Z535.4:

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

Warning Labels

A popular research topic has been the effect of product familiarity on warning compliance. Research has consistently shown that increased product familiarity leads to a decreased likelihood that the warning will be followed, or even read. This finding has been replicated across a variety of situations and products, including: 1) swimming pools; 2) all terrain vehicles (ATVs); and 3) tampons (Goldhaber and deTurck, 1988; Godfrey and Laughery, 1984; Karnes, Leonard, and Rachwal, 1986).

Perhaps the most powerful finding has been that the perceived probability of an accident has an effect on warning compliance and safety behavior. Bogett and Rodriguez (1987) found that a perception of danger (i.e., an unacceptable risk of loss or injury) must exist in order for a person's safety behavior to be elevated. With respect to warnings, it has been shown that warnings are more likely to be read when they are placed on equipment that is perceived as dangerous than when they appear on equipment perceived as less dangerous (Otsubo, 1988). Moreover, mere willingness to read warnings increases as the perceived hazardousness of the product increases (Wogalter, Desauliniers, and Brelsford, 1988). Wogalter, Desauliniers, and Brelsford (1987) also concluded that expected severity of injuries resulting from not complying with the warning is more predictive of perceived product hazardousness than perceived likelihood of an accident. In addition, they concluded that product hazardousness is highly correlated with the level of caution people reportedly exercise when using the product.

Unfortunately, research has concluded, time and again, that people cannot accurately estimate risk. The fact that people consistently underestimate common risks and overestimate rare risks is common knowledge in the social sciences (e.g., Godfrey, 1987; Dunn, 1972). Fortunately, researchers have found that statements of the consequences of disregarding warnings has an effect on the attention to, and memory for, warnings. Slovic (1987) stated that reporting the probability of an accident over one's lifetime, as opposed to the probability for any given day, has been successful in inducing insurance against the rarest hazards in insurance experiments.

The cost of complying to the warning also significantly affects individual's willingness to comply. Warnings that require great amounts of time, or inconvenience, to obey are more likely to be ignored than warnings that require little or no lost time (Wogalter, McKenna, and Allison, 1988). In addition, the behavior of other people can bias the compliance of individuals. For example, when subjects witness another person obeying a warning they are more likely to obey the warning themselves (Wogalter, McKenna, and Allison, 1988).

Physical characteristics of warning labels have also been shown to affect compliance. First, the preferred warning symbol shape is a triangle on its vertex, followed by an oval (Riley, Cochran, and Ballard, 1982; Cunitz, 1981). Second, research has shown that the color of a warning, in and of itself, is not a significant factor in label identification. If, however, the warning is deficient in some other aspect which causes it to be unclear, color has been shown to be an effective coding characteristic (Lowenthal and Riley, 1980; Easterby and Haikel, 1981). Cunitz (1981) concluded that standardized warning colors (e.g., red, yellow, and black stripes) have greater attention-getting ability than other colors. Third, the warning text must answer the question, "Why should I obey?". The instructions must be explicit (e.g., "STEP DOWN" vs. "WATCH YOUR STEP") and not cause motivational conflict. For instance, a warning, "DO NOT REMOVE GUARD", is not likely to be obeyed if the guard has to be removed to perform regular maintenance. Moreover, in opposition to the recommendations set forth by FMC, the warning should begin with the critical information (e.g., "WEAR SAFETY GOGGLES" vs. "DANGER: HAZARDOUS TO EYES") (Strawbridge, 1986). Fourth, Easterby and Haikel (1981) concluded that there is a strong tendency for descriptive signs to be understood better than injunctive signs.

The utilization of pictorials on product safety signs are becoming more prominent. As discussed by Baker and Aherin (1988), pictorials enhance the recognition of the hazard during the mental processing of the warning message. Belmore (1981) stated:

> "The modern use of symbol (pictorial) signs has expanded rapidly to include most sign applications, including those for highways, machinery, and buildings. Among the major advantages of symbols are that they can, in some cases, be perceived more rapidly, more accurately, and at a greater distance than can words. Reaction time to symbols may be shorter, even under visual degradation. Symbol meanings can often be rapidly learned and accurately remembered, with minimal confusion among alternatives. Symbols may also be superior to words under conditions of interference, including distraction from another task and visual interference or degradation".

Studies have shown that people tend to have a significant higher recall of information presented in the form of pictorials as opposed through the use of words (Erdelyi and Becker, 1974; Shapiro and Erdelyi, 1974; Erdelyi, 1977; FMC, 1985). Additionally, picture recall tends to increase over time. Whereas, the recall of words tends to be constant over time. There is no significant difference in the ability of persons to recall pictures as opposed to the recall of pictures that are also accompanied with a word description. People tend to be able to comprehend messages better that can be recalled in the form of pictures as opposed to thoughts.

In a study conducted by Baker and Aherin (1988) a variety of pictorials were presented to audiences of farm equipment users. In separate tests, definitions for each pictorial were supplied by one group of subjects and another group of subjects evaluated a set of pictorials for effective communication. The results of this testing indicated:

1. The bold representation of the human form is more effective than a line drawing of the same figure in communicating the message.
2. The representation of the human form should be dramatically involved with the machine element.
3. The machine element should be a stylistic representation of the particular hazard area and not a generic representation of the machine elements.
4. The use of color to represent blood should be avoided.
5. The universal prohibition symbol (circle with diagonal slash) is not effective. The circle and slash often obscure the proposed symbol to be placed within the circle. This prohibition symbol is not well understood in most applications other than for a few traffic signs and no smoking signs.

Warnings that appear in the format of instructions have unique research findings that need to be addressed. First, instructions presented in the affirmative are recalled better than instructions presented in the negative (File and Jew, 1973). Second, the tense of the instructions does not effect recall (i.e., active vs. passive) (File and Jew, 1973). Third, the text should be in conspicuous print in order to maximize the recall of the verbal warning content (e.g., larger print with color highlighting). Fourth, if icons are present they must be meaningfully related to the text (Young and Wogalter, 1988). Fifth, as noted earlier, Strawbridge (1986) concluded that imbedding warning information severely restricts the percentage of compliance exhibited by the subjects. In order to maximize the compliance rate the critical information should be presented first (e.g., "WEAR SAFETY GOGGLES" vs. "DANGER: HAZARDOUS TO EYES").

Safety Messages in Product Manuals

The same principles apply in developing safety instructional messages for product manuals as they do for safety signs (Baker and Aherin, 1988). Safety instructions in product manuals should provide more detailed information regarding potential severity of injury, the probability of not following the recommended practice resulting in a severe injury or death, and how to practically avoid or reduce the risk. Pictorials should be used where practical to enhance the recognition of the hazard by the product user. Warnings contained in operators manuals should be presented in an organized format. This allows warnings to be more comprehensible to product users as opposed to warnings on products, where the information is scattered over the product.

Chapter VI
Conclusions and Recommendations

This work has been a review of several bodies of literature that have some bearing upon agricultural safety and health problems and issues. However, this review is by no means exhaustive. The following are a series of conclusions and recommendations the authors have derived from this study.

Conclusion No. 1

Production agriculture has several unique characteristics that impact upon its safety and health problems. The most difficult of these include: children in the workplace, young and untrained workers, and aged workers; a working class that has a relatively low economic status; and a culture that has traditionally not supported the type of safety and health interventions used by other industries.

Recommendation A. The uniqueness of agriculture's safety and health problems need to be clearly communicated to both agricultural and non-agricultural populations as a way of encouraging more creative injury intervention strategies.

Recommendation B. Agricultural organizations, businesses, industries, land grant universities, medical and health groups, and professional societies need to become more visible in their support of agricultural safety and health as a way to create a culture and value system among farm workers and families that includes farm safety and health practices.

Conclusion No. 2

Agricultural injury data gathering has not progressed beyond the descriptive stage and is marked by inconsistent data treatment. This tends to obscure the agricultural injury and illness picture. There is almost no specific exposure data collected to accurately describe levels of risk for subgroups of workers or for major agents of injury. There is little data, for example, to identify the level of risk a particular age or sex group has in working with a specific type of machine, nor at a particular type of job.

Recommendation C. A concerted effort is needed to collect risk and injury exposure data to guide injury control interventions. This need is far greater than additional studies to collect descriptive data.

Conclusion No. 3

There has been practically no systematic evaluation of the effectiveness of agricultural safety and health education, legislation, or engineering efforts to prevent or control agricultural injuries.

Recommendation D. Agricultural safety and health professionals from all disciplines need to undertake scientific evaluations of their disciplines efforts to prevent agricultural injuries.

Conclusion No. 4

There appears to be very little machinery safety engineering research at major agricultural universities, and no recognition of safety engineering or safety research as an important research area within the United States Department of Agriculture (USDA). Nor do agricultural machinery manufacturers appear to support machinery safety engineering research commensurate with the number and seriousness of agricultural machinery injuries.

Recommendation E. The USDA and machinery manufacturers should embark on a vigorous program of public machinery safety engineering research to further eliminate and reduce machinery hazards. This program should include the development of priorities, research faculty, and funding.

Conclusion No. 5

There is a clear and unambiguous record of effective intervention strategies and approaches in other industries and with other major agents of injury. It is not readily apparent that agriculture has seriously considered these strategies and approaches.

Recommendation F. Agricultural safety and health professionals from all disciplines should become more knowledgeable of specific injury control strategies and approaches successfully used in other industries with an eye on their potential application to agriculture.

Recommendation G. Agricultural safety and health professionals from all disciplines should develop a comprehensive, overall strategy for attacking agricultural safety and health problems. The development of this plan should encompass the views and skills of all interested parties.

Conclusion No. 6

Traditional population-based safety and health education programs have little likelihood of success in agriculture. However, several practical and cultural considerations suggest education oriented approaches will continue to be an important option for the prevention and control of agricultural injuries and illnesses. More recently developed theories of behavioral analysis and prediction show promise of providing researchers and educators with a more thorough and comprehensive understanding of safety and health related behaviors and of methods for modifying those behaviors. In turn, these new behavioral analysis methods have some potential for directing effective educational initiatives.

Recommendation H. Agricultural safety and health researchers and educators should become more familiar with the concepts and foundations of applied behavioral analysis.

Recommendation I. A limited research program should begin in the application of applied behavioral analysis to agricultural safety and health. Initially, a single research question of high national importance should be selected for study. This will provide some empirical evidence of the utility of behavioral analysis methods for agricultural safety and health problems.

Conclusion No. 7

Farm machines, equipment, and structures often have warnings that instruct and encourage users to be aware of hazards, and to use or handle the machine or facility only in the recommended way. The effectiveness of warning signs to convey important safety and health education messages is severely compromised by: product familiarity; low perceived likelihood of an injury; observed noncompliance with warnings by others; motivational conflicts (i.e., warning says "do not remove guard" when removal is sometimes required); and compliance costs (financial, effort, convenience). Conversely, warning effectiveness is greatest for those products that are perceived to be very hazardous. There is a well developed body of literature on major elements for warning messages.

Recommendation J. Message content and layout on warning signs currently used for agricultural machinery and structures should be examined for compliance with recommended design criteria, and upgraded as needed.

Conclusion No. 8

The specific type of media or visuals used to convey information is relatively unimportant. Conversely, perceived credibility, expertise, position power of the presenter, a large number of reasons or arguments for a position, stating instructions in a positive manner, and similarity between the communicator and the audience is important.

Recommendation K. Safety and health professionals should use a wide variety of print and visual mediums to communicate farm safety and health information. Television and videotape presenters should be respected, high profile figures able to establish credibility with farm workers and their families.

Conclusion No. 9

The use of moderate levels of fear or frightening scenes is effective in persuading behavior. If high levels of fear or fright are used, avoidance behaviors and defense mechanisms will lessen the effectiveness of information presented. The same inverted U function is true with repeated messages (i.e., Repeating safety messages is effective until it reaches the point where it becomes irritating to the audience).

Recommendation L. Pictures and visuals used for safety and health messages and instructions should be realistic but not overwhelmingly gruesome. Variations of a central concept message should be produced for maximum retention and effectiveness.

References

Aherin, R. A. 1987. *The prediction and analysis of safety behaviors among dairy farmers in central Wisconsin.* Unpublished Ph.D. diss., University of Minnesota, Minneapolis, MN.

Aherin, R. A. and C. M. Todd. 1989. Accident risk taking: Behavior and injury experience of farm youth. ASAE Paper No. 89-5530. St. Joseph, MI: ASAE.

Ajzen, I. 1985. From intentions to actions: A theory of planned behavior. In *Action Control,* eds. J. Kuhl and J. Beckman, 11-39. New York: Springer-Verlag.

———. 1991. A theory of planned behavior: Some unresolved issues. *Organizational Behavior and Human Decision Processes* 50:179-211.

Ajzen, I. and M. Fishbein. 1980. *Understanding Attitudes and Predicting Social Behavior.* Englewood Cliffs, NJ: Prentice-Hall.

American Farm Bureau Federation. 1977. *Farm Bureau policies for 1977.* Park Ridge, IL.

American Public Health Association. 1961. *Accident Prevention.* New York.

Anderson, K. C. and G. L. Smith. 1988. Human presence activated safety systems for mobile off-road equipment. ASAE Paper No. 88-5516. St. Joseph, MI: ASAE.

Aronson, E., J. A. Turner and J. M. Carlsmith. 1963. Communicator credibility and communication discrepancy as determinants of opinion change. *Journal of Abnormal and Social Psychology* 67:31-36.

ASAE Standards, 37th Ed. 1990. S318.10. Safety for agricultural equipment. St. Joseph, MI: ASAE.

———. 1990. S383.1, Rollover protection structure (ROPS) for wheeled agricultural tractors. St. Joseph, MI: ASAE.

Baker, L. D. and R. A. Aherin. 1988. Product safety – A new direction. *Transactions of the SAE* 96(5):5.260-5.269.

Bandura, A. 1977. *Social Learning Theory.* Englewood Cliffs, NJ: Prentice Hall.

———. 1991. Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes* 50:248-287.

Bandura, A. and D. Cervone. 1983. Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of Personality and Social Psychology* 45:1017-1028.

Bandura, A. and R. Wood. 1989. Effect of perceived controllability and performance standards on self-regulation of complex decision-making. *Journal of Personality and Social Psychology* 56:805-814.

Barnett, R. L. and D. B. Brickman. 1986. Safety hierarchy. *Journal of Safety Research* 17:49-55.

Bayer, D. L. 1984. The benefits of a farm safety program. *California Agriculture* 38(1&2):26-27.

Beck, K. H. and A. K. Lund. 1981. The effects of health threat seriousness and personal efficacy upon intentions and behavior. *Journal of Applied Social Psychology* 11:401-415.

Becker, W. J. and W. D. Shoup. 1986. Cost/benefits of safety training for citrus workers. Paper No. 86-1. Paper presented at the summer meeting of the National Institute of Farm Safety, Orlando, FL.

Belmore, S. M. 1981. Imagery and semantic elaboration in hypermnesia for words. *Journal of Experimental Psychology: Human Learning and Memory* 7:191-203.

Bennett, J. F. 1990. Signs of the time. *Agricultural Engineering* 71(6):10-12.

Bentham, J. 1879. *An Introduction to the Principles of Morals and Legislation.* Oxford: Clarendon (original work published in 1789).

Blehm, K. D. 1989. Perspectives on agricultural safety and health. *Applied Industrial Hygeine* 4(10):F22-25.

Bodycombe, B. 1986. Safety incentives: theory and practice. *Safety Practitioner* 4:18-20.

Bogett, W. R. and L. Rodriguez. 1987. On the influence of a perception of danger on the effectiveness of warnings for product users. *Hazard Prevention* 23(4):19-24.

Brock, T. C. 1965. Communicator-recipient similarity and decision change. *Journal of Personality and Social Psychology* 650-654.

Brown, I. D. 1982. Driver behavior. In *Pedestrian Accidents,* eds. A. J. Chapman, F. M. Wade and H. C. Foot. Chichester: Wiley.

Burke, J. 1976. A bicentennial look at safety. *Farm Safety Review* 34(4):3-12.

———. 1987. Historical overview of the agricultural safety movement. ASAE Paper No. 87-5512. St. Joseph, MI: ASAE.

Cacioppo, J. T. and R. E. Petty. 1979. Effects of message repetition and position on cognitive response, recall, and persuasion. *Journal of Personality and Social Psychology* 37(1): 97-100.

Campbell, W. P. 1987. *The condition of agricultural driveline system shielding and its impact on injuries and fatalities.* Unpublished M.S. thesis. West Lafayette, IN: Purdue University.

Campbell, J. D., A. Tesser and P. J. Fairey. 1986. Conformity and attention to the stimulus: Some temporal and contextual dynamics. *Journal of Personality and Social Psychology* 51(2):315-324.

Chaiken, S. 1979. Communicator physical attractiveness and persuasion. *Journal of Personality and Social Psychology* 37:1387-1397.

———. 1980. Heuristic versus systematic information processing and the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology* 39(5):752-766.

Chapanis, A. 1980. Human factors engineering for safety. *Professional Safety* 25(7):16-24.

Clark, R. E. 1983. Reconsidering research on learning from media. *Review of Educational Research* 53(4):445-459.

Clark, R. C. and R. E. Clark. 1984. Instructional media vs. instructional methods. *Performance and Instruction Journal* 23(5):1-3.

Cohen, A., M. J. Smith and W. K. Anger. 1979. Self-protective measures against workplace hazards. *Journal of Safety Research* 11:121-131.

Colorado State University. 1982. *Workplace health in agriculture program: Final progress report*. Fort Collins, CO.

Cook, T. D. and D. T. Campbell. 1979. *Quazi-Experimentation: Design and Analysis Issues for Field Settings*. Boston: Houghton Mifflin.

Coughenour, C. M. and L. Swanson. 1983. Work statuses and occupations of men and women in farm families and the structure of farms. *Rural Sociology* 48(1):23-43.

Cunitz, R. J. 1981. Psychologically effective warnings. *Hazard Prevention* (May/June) 17(3):5-7.

Dawson, R. F. F. and P. F. Everell. 1972. *The Value of Motorists' Time: A Study in Italy*, Report 426. Crowthorne: Transport and Road Research Laboratory.

DeReamer, R. 1980. *Modern Safety and Technology*. New York: John Wiley & Sons.

Dhillon, B. S. 1986. *Human Reliability with Human Factors*. New York: Pergamon Press.

Dunn, J. G. 1972. Subjective and objective risk distribution. *Occupational Psychology* 46:183-187.

Eagly, A. H. and R. Warren. 1976. Intelligence, comprehension, and opinion change. *Journal of Personality* 44:226-242.

Easterby, R. S. and S. R. Hakiel. 1981. Field testing of consumer safety signs: The comprehension of pictorially presented messages. *Applied Ergonomics* 12(3):143-152.

Ellman, E. and T. J. Killbrew. 1978. Incentives and seatbelts: Changing a resistant behavior through extrinsic motivation. *Journal of Applied Social Psychology* 8:72-83.

Erdelyi, M. H. 1977. *Has Ebbinghaus decayed with time?* Paper presented at the 18th annual meeting of the Psychonomics Society, Washington, DC.

Erdelyi, M. H. and J. Becker. 1974. Hypermnesia for pictures: Incremental memory for pictures but not words in multiple recall trials. *Cognitive Psychology* 6:159-171.

Etherton, J., J. Myers, R. Jensen and R. Braddee. 1989. *Agricultural machine safety research: Fatality prevention targeting*. Paper presented at the annual meeting of the American Public Health Association, Chicago, IL.

Etherton, J. and J. Myers. 1990. The use of rollover protection on farm tractors in West Virginia. In *Advances in Industrial Ergonomics II*, ed. B. Das, 819-825. Philadelphia, PA: Taylor & Francis.

Experiment Station Committee on Organization and Policy. 1990. *Research agenda for the 1990s: A stategic plan for the state agricultural experiment stations*. ESCOP 90-1. College Station, TX: Texas A&M University System.

Federal Register. 1971. *Occupational safety standards: national consensus standards and established federal standards*. 36:105. May. Washington, DC: GPO.

Fellner, D. J. and Sulzer-Azaroff. 1984. Increasing industrial safety practices and conditions through posted feedback. *Journal of Safety Research* 15:7-21.

Festinger, L. 1957. *A Theory of Cognitive Dissonance*. Evanston, IL: Row, Peterson.

Field, W. E. and R. W. Bailey. 1976. *A summary of the 1976 Indiana farm accident survey with a brief analysis of fatalities on Indiana farms, 1973-1976*. Cooperative Extension Service, Purdue University, West Lafayette, IN.

Field, W. E. and R. L. Tormoehlen. 1982. *Analysis of fatal and non-fatal farm accidents involving children*. ASAE Paper No. 82-5501. St. Joseph, MI: ASAE.

Fischhoff, B., L. Furby and R. Gregory. 1987. Evaluating voluntary risks of injury. *Accident Analysis and Prevention* 19: 51-62.

Fischhoff, B., S. Lichtenstein, P. Slovic, S. L. Derby and R. L. Keeney. 1981. *Acceptable Risk*. Cambridge University Press.

Fishbein, M. and I. Ajzen. 1975. *Belief, Attitudes, Intention and Behavior*. Massachusetts: Addison-Wesley.

FMC. 1985. *Product safety sign and label system*. (Report). Santa Clara, CA.

Fogarty, B. 1989. Maybe you're not involved enough. *Implement and Tractor* (July):6-7, 29.

Fox, B. H. 1961a. Research. In *Accident Prevention*. New York: American Public Health Association.

———. 1961b. Discussion. In *Behavioral Approaches to Accident Research*. New York: Association for the Aid of Crippled Children.

Fox, D. K. 1976. Effects of an incentive program on safety performance in open-pit mining in Utah's Shirley Basin Mine, Wyoming. Paper to Midwest Analysis of Behavior Association, Chicago.

Freeman, N. T. 1972. Creative incentive schemas. *Occupational Safety and Health* 22-26.

Geller, E. S. 1983. Rewarding safety belt usage at an industrial setting: Tests of treatment generality and response maintenance. *Journal of Applied Behavioral Analysis* 16:189-202.

Geller, E. S. 1986. Incentive/reward strategies for community-based behavior change. Proc. Conf. Dynamics of social change: Applications for safety, Edmonton, Traffic Injury Research Foundation, Ottawa.

Gibson, J. 1961. The contribution of experimental psychology to the formulation of the problem of safety-A brief for basic research. In *Behavioral Approaches to Accident Research*. New York: Association for the Aid of Crippled Children.

Godfrey, S. S. 1987. *A method for correcting biases in risk perception*. Paper presented at the Human Factors Society 31st Annual Meeting, 484-487.

Godfrey, S. S. and K. R. Laughery. 1984. *The biasing effects of product familiarity on consumer's awareness of hazard*. Proceedings of the Human Factors Society 28th Annual Meeting, 483-486.

Goldhaber, G. M. and M. A. deTurck. 1988. Effects of consumers' familiarity with a product on attention to and compliance with warnings. *Journal of Product Liability* 11:29-37.

Gorn, G. 1982. The effects of music in advertising on choice behavior: A classical conditioning approach. *Journal of Marketing Research* 46:94-101.

Guastello, S. J. 1989. Catasrophe modelling of the accident process: Evaluation of an accident reduction program using the occupational hazards survey. *Accident Analysis and Prevention* 21 (1):61-77.

Haddon, W., Jr. 1963. A note concerning accident theory and research with special reference to motor vehicle accidents. *Annuals of New York Academy of Sciences* 107:635-646.

———. 1968. The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. *American Journal of Public Health* 58(8):1431-1438.

———. 1970. On the escape of tigers: An ecologic note. *Technology Review* 72:44-53.

———. 1980. Advances in epidemiology. *Public Health Report* 95:411-421.

Haddon, W., Jr. and S. P. Baker. 1981. Injury control. In *Preventive and Community Medicine*, 2nd Ed. eds. D. W. Clark and B. MacMahon, 109-140. Boston, MA: Little, Brown, & Company.

Hale, A. R. and I. A. Glendon. 1987. *Individual Behavior in the Control of Danger*. Elsevier, Amsterdam: Elsevier Science Publishers B. V.

Hammer, W. 1985. *Occupational Safety Management and Engineering*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Harkins, S. G. and R. E. Petty. 1981. Effects of source magnification of cognitive effort on attitudes: An information processing view. *Journal of Personality and Social Psychology* 40(3):401-413.

Haverstock, L. M. 1989. Farm stress: Research considerations. In *Principles of Safety and Health in Agriculture*, eds. J. A. Dosman and D. W. Cockcroft, 381-384. Boca Raton, FL: CRC Press, Inc.

Heesacker, M., R. E. Petty and J. T. Caccioppo. 1983. Field dependence and attitude change: Source credibility can alter persuasion by affecting message-relevant thinking. *Journal of Personality* 51(4): 653-666.

Heider, F. 1958. *The Psychology of Interpersonal Relations*. New York: Wiley.

Heinrick, H. W. 1959. *Industrial Accident Prevention*, 4th Ed. New York: McGraw-Hill Publishing Co.

Higbee, K. L. 1969. Fifteen years of fear arousal: Research on threat appeals, 1953-1968.

Hollenbeck, J. R. and H. J. Klein. 1987. Goal commitment and the goal-setting process: Problems, prospects, and proposals for future research. *Journal of Applied Psychology* 72:212-220.

Hovland, C. I. and I. L. Janis. 1959. Summary and implications for further research. In *Personality and persuasibility*, eds. C. I. Hovland and I. L. Janis. New Haven, CT: Yale University Press.

Hovland, C. I. and H. A. Pritzker. 1957. Extent of opinion change as a function of amount of change advocated. *Journal of Abnormal and Social Psychology* 54:257-261.

Huizinga, M. A. and D. J. Murphy. 1988. Utilizing Pennsylvania farm work exposure and injury data. ASAE Paper No. 88-5517. St. Joseph, MI: ASAE.

Hutchinson, M. K. 1973. *Protecting the health of coal miners: An interagency approach*. National Institute for Occupational Safety and Health. HSM 73-11015. Washinton, DC: GPO.

Ingersol, B. 20 July 1989. Farming is dangerous, but fatalistic farmers oppose safety laws. *Wall Street Journal*, pp. A1, A4.

International Labour Office. 1987. *Safety and health in construction*. International Labour Conference, Report V(1), Geneva, Switzerland.

Jamison, D., P. Suppes and S. Wells. 1974. The media effectiveness of alternative instructional media: A survey. *Review of Educational Research* 44:1-68.

Janis, I. L. 1967. Effects of fear arousal on attitude change: Recent developments in theory and experimental research. In *Advances in Experimental Social Psychology*, ed. L. Berkowitz, 3:166-224. New York: Academic Press.

Janz, N. K. and M. H. Becker. 1984. The health belief model: A decade later. *Health Education Quarterly* 11(1):1-47.

Jensen, D. V. 1978. *Fatal farm accidents in Wisconsin*. Publication No. A2303. University of Wisconsin-Extension, University of Wisconsin, Madison.

Jepsen, R. L. 1981. Fatal agricultural accidents in Kansas: 1976-1980. Publication No. MF636. Cooperative Extension Service, Kansas State University, Manhattan.

Kahneman, D., P. Slovic and A. Tversky. 1982. *Judgment and Uncertainty: Heuristics and Biases*. New York: Cambridge University Press.

Kahneman, D. and A. Tversy. 1973. On the psychology of prediction. *Psychological Review* 80:237-251.

Kahneman, D. and A. Tversky. 1984. Choices, values, and frames. *American Psychologist* 39:341-350.

Kansas State Board of Health. 1957. *Agricultural accidental death report*. Topeka, KS: Division of Vital Statistics.

Karlson, T. and J. Noren. 1979. Farm tractor fatalities: the failure of voluntary safety standards. *American Journal of Public Health* 69(2):146-149.

Karnes, E. W., S. D. Leonard and G. Rachwal. 1986. Effects on benign experiences on the perception of risk. Paper presented at the Human Factors Society 30th Annual Meeting, 121-125.

Keen, J. and R. Walmer. 30 October 1989. Danger on *USA farms*. USA Today, pp. 1A, 8A.

Keinan, G. 1987. Decision-making under stress: Scanning of alternatives under controllable and uncontrollable threats. *Journal of Personality and Social Psychology* 52:639-644.

Klein, D. and J. A. Waller. 1970. *Causation, culpability, and deterence in highway crashes*. Washington, DC: Department of Transportation.

Krause, T. R. and J. H. Hidley. 1989. *Behavioral Science Methods for Accident Prevention*. Ojai, California: Behavioral Science Technology, Inc.

Landy, F. and W. Becker. 1987. Motivation theory reconsidered. *Research in Organizational Behavior* 9:1-38.

Langer, E. J. 1975. The illusion of control. *Journal of Personality and Social Psychology* 32:311-318.

Levenson, H. M., M. L. Hirschfield, A. Hirschfield and A. Dzubay. 1983. Recent life events and accidents: The role of sex differences. *Journal of Human Stress* 9(1):4-11.

Levanthal, H., R. Singer and S. Jones. 1965. Effects of fear and specificity of recommendations upon attitudes and behavior. *Journal of Personality and Social Psychology* 2:20-29.

Lichtenstein, M. and T. K. Srull. 1985. Conceptional and methodological issues in examining the relationship between consumer memory and judgement. In *Psychological Processes and Advertising Effects: Theory, Research, and Applications*, eds. L. F. Alwitt and A. A. Mitchell, 113-128. Hillsdale, New Jersey: Erlbaum.

Likert, R. 1932. A technique for the measurement of attitudes. *Archives of Psychology* 140.

Litovitz, T. L., B. F. Schmitz and K. C. Holm. 1988. The 1988 annual report of the American Association of Poison Control Centers. *American Journal of Emergency Medicine* 7(5):495-534.

Locke, E. 1990. *A Theory of Goal-Setting and Task Performance*. NJ: Prentice-Hall.

Locke, E. A., G. P. Latham and M. Erez. 1988. The determinants of goal commitment. *Academy of Management Review* 13:23-39.

Loewenthal, A. and M. W. Riley. 1980. The effectiveness of warning labels. Paper presented at the Human Factors Society 24th annual meeting.

Lorge, I. 1936. Prestige, suggestion, and attitudes. *Journal of Social Psychology* 7:386-402.

Maddux, J. E. and R. W. Rogers. 1980. Effects of source expertness, physical attractiveness, and supporting arguments on persuasion: A case of brains over beauty. *Journal of Personality and Social Psychology* 39(2):235-244.

Maslow, A. H. 1970. *Motivation and Personality*. New York: Harper & Row.

Mausner, J. S. and S. Kramer. 1985. *Epidemiology: An Introductory Text*. Philadelphia, PA: W. B. Saunders Co.

McClintic, D. 1990. Letting go. *The Furrow* 95(3):30-32.

McClure, W. R. and B. J. Lamp. 1961. An analysis of 212 fatal Ohio farm tractor accidents. ASAE Paper No. 61-129. St. Joseph, MI: ASAE.

McGuire, W. J. 1985. Attitudes and attitude change. In *Handbook of Social Psychology*, 3rd Ed. eds. G. Lindzey and E. Aronson, 2:223-346. New York: Random House.

Mittal, D. 1987. Habit and intentions: A study of seat belt usage. *Journal of Experimental Social Psychology* 32:76-92.

Monforten, R., T. Dumula, A. Yanik and F. Richter. 1988. *Accident experience of older AAA drivers in Michigan: Effects of aging on driver performance*. SP-762. Warrendale, PA: Society of Automotive Engineers.

Murphy, D. J. 1985a. *Pennsylvania farm fatalities during 1980-84*. Special Circular 319. Cooperative Extension Service, Penn State University, University Park, PA.

———. 1985b. Agricultural safety and health educational program effectiveness. Paper No. 85-4. Paper presented at the annual meeting of the National Institute for Farm Safety, St. Louis, MO.

———. 1985c. Realities of safety education. *Professional Safety* 3(7):15-19.

Myers, J. 1989. The national traumatic occupational fatalities: A surveillence tool for agricultural work-related deaths. Paper No. 89-9. Presented at the summer meeting of the National Institute For Farm Safety, Monterrey, CA.

Napier, T. L., W. R. Goe and A. R. Pugh. 1985. Incidence and predictive factors associated with farm accidents in Ohio. Research Circular 287. Ohio Agricultural Research and Development Center, Ohio State University, Wooster.

National Academy of Sciences. 1985. *Injury in America: A continuing health problem*. Washington, DC: GPO.

———. 1988. *Injury control*. Washington, DC: NAS.

National Association of State Universities and Land-Grant Colleges. 1990. Strategic investments for agricultural research, extension and higher education for fiscal 1991: a report by the fiscal 1991 budget committee division of agriculture. Washington, DC.

National Committee for Injury Prevention and Control. 1989. *Injury Prevention: Meeting the Challenge*. New York: Oxford University Press.

National Institute for Occupational Safety and Health. 1989. *National traumatic occupational fatalities: 1980-1985*. Morgantown, WV: NIOSH.

National Safety Council. 1960. Julien Harvey dies, author of "three e's". *National Safety News* 81(4).

———. 1974. *A procedure for collecting farm accident data*, 3rd rev. Chicago, IL.

———. 1978. *Accident facts: 1978 edition*. Chicago, IL.

———. 1982. *1982 farm accident survey report*. Chicago, IL.

———. 1990. *Accident facts*: 1990 Edition. Chicago, IL: Author.

———. 1991. *Accident facts*: 1991 Edition. Chicago, IL.

Naylor, J. D., R. D. Pritchard and D. R. Ilgen. 1980. *A Theory Behavior in Organizations*. New York: Academic Press.

Norman, R. 1976. When what is said is important: A comparison of expert and attractive sources. *Journal of Experimental Social Psychology* 12:294-300.

Osgood, C. E., G. J. Suci and P. H. Tannenbaum. 1957. *The Measurement of Meaning*. Urbana: University of Illinois Press.

Otsubo, S. M. 1988. A behavioral study of warning labels for consumer products: Perceived danger and the use of pictographs. Paper presented at the Human Factors Society 32nd Annual Meeting.

Pavlov, I. P. 1927. *Conditioned Reflexes*. New York: Oxford Univ. Press.

Petersen, D. 1975. *Safety Management: A Human Approach*. Fairview, NJ: Aloray Publisher.

Petty, R. E., J. T. Cacioppo and R. Goldman. 1981. Personal involvement as a determinant of argument-based persuasion. *Journal of Personality and Social Psychology* 40.

Petty, R. E. and J. T. Cacioppo. 1986. The elaboration likelihood model of persuasion. *Advances in Experimental Social Psychology* 19:123-205.

Piccolino, E. B. 1966. *Depicted Threat, Realism and Specificity: Variables Governing Safety Posters' Effectiveness*. Unpublished diss., Chicago: Illinois Institute of Technology.

Piercy, L. R. and L. Stallones. 1984. Fatal accidents on Kentucky farms. ASAE Paper No. 84-5508. St. Joseph, MI: ASAE.

Purschwitz, M. A. 1990. *Fatal Farm Injuries to Children*. Marshfield, WI: Marshfield Medical Research Foundation.

Purschwitz, M. A. and W. E. Field. 1987. Scope and magnitude of injuries in the agricultural workplace. ASAE Paper No. 87-5514. St. Joseph, MI: ASAE.

———. 1986. Farm related fatalities involving persons 60 years of age and older. Paper No. 86-6. Paper presented at the summer meeting of the National Institute of Farm Safety, Orlando, FL.

Reason, J. T. 1976. Absent minds. *New Society* 4:244-245.

Reason, J. T. and K. Mycielska. 1982. *Absent Minded? The Psychology of Mental Lapses and Everyday Errors*. Englewood Cliffs, New Jersey: Prentice-Hall.

Reber, R. A. and J. A. Wallin. 1984. The effects of training, goal setting, and knowledge of results on safe behavior: A component analysis. *Academy of Management Journal* 27:544-560.

Riley, M. W., D. J. Cochran and J. L. Ballard. 1982. An investigation of preferred shapes for warning labels. *Human Factors* 24(6):737-742.

Rivara, F. P. 1985. Fatal and non-fatal farm injuries to children and adolescents in the United States. *Pediatrics* 76(4):567-573.

Robertson, L. S. 1983. *Injuries: Causes, Control and Public Policy*. Lexington, MA: Lexington Books.

Robinson, J. 1982. *Stress and How to Live with It*. Meredith Corporation: U.S.

Rogers, R. W. 1975. A protection motivation theory of fear appeals and attitude change. *The Journal of Psychology* 91:93-114.

Rosenstock, I. M., V. J. Strecher and M. H. Becker. 1988. Social learning theory and the health belief model. *Health Education Quarterly* 15:175-183.

Rothman, K. J. 1986. *Modern Epidemiology*. Boston, MA: Little, Brown & Company.

Sanders, M. S. and E. J. McCormick. 1987. *Human Factors in Engineering and Design*. New York: McGraw-Hill Book Co.

Savage, L. J. 1954. *The Foundations of Statistics*. New York: Wiley.

Schafer, S. R. and J. W. Kotrlik. 1986. Factors affecting farm safety procedures. *Journal of Safety Research*, 17:123-127.

Schultz, L. D. 1985. Minnesota farm work-related accidental deaths: 1984. Agricultural Extension Service, University of Minnesota, St. Paul.

Secretary of Transportation. 1971. Agricultural tractor safety on public roads: A report to congress. Washington. DC: U.S. Department of Transportation.

Sevart, J. B. 1987. *Personal protective devices on agricultural equipment*. ASAE Paper No. 87-5517. St. Joseph, MI: ASAE.

Shapiro, S. R. and M. H. Erdelyi. 1974. Hypermnesia for pictures but not words. *Journal of Experimental Psychology* 103:1218-1219.

Silletto, T. A. 1976. Implications for agricultural safety education programs as identified by Iowa farm accident survey. An unpublished Ph.D. diss., Iowa State University, Ames.

Skinner, B. F. 1938. *The Behavior of Organisms*. New York: Appelton-Century-Crofts.

———. 1953. *Science and Human Behavior*. New York: Macmillan & Sons.

Slovic, P. 1987. Perception of Risk. *Science* 236:280-285.

Slovic, P., S. Lichtenstein and B. Fischhoff. 1984. Modelling the societal impact of fatal accidents. *Management Science* 30:464-474.

Small, A. M. 1987. Design for older people. In *Handbook of Human Factors*, ed. G. Salvendy, 495-504. New York: John Wiley & Sons.

Snyder, M. and K. G. Debono. 1985. Appeals to image and claims about quality: Understanding the psychology of advertising. *Journal of Personality and Social Psychology* 49:586-597.

Stallones, L. 1989. Fatal unintentional injuries among Kentucky farm children: 1979 to 1985. *Journal of Rural Health* 5(3):246-256.

Steffy, R. A., W. C. Corning, C. Anderson and P. Bowers. 1986. Maturational lag profiles. Follow-up analysis. *Journal of Abnormal Child Psychology* 14(2):235-249.

Strawbridge, J. A. 1986. The influence of position, highlighting, and imbedding of warning effectiveness. *Proceedings of the Human Factors Society* 716-720.

Stroebe, W. and M. Diehl. 1981. Conformity and counterattitudinal behavior: The effect of social support on attitude change. *Journal of Personality and Social Psychology* 41(5):876-889.

Stueland, D. and B. L. Lee. 1989. Agents associated with agricultural injuries in central Wisconsin: An initial evaluation. Paper No. 89-1. Paper presented at the summer meeting of the National Institute for Farm Safety, Monterrey, CA.

Suchman, E. A. 1961. A conceptual analysis of the accident phenomenom. In *Behavioral Approaches to Accident Research*. New York: Association for the Aid of Crippled Children.

Surry, J. 1977. *Industrial Accident Research: A Human Engineering Appraisal*. Toronto, Ontario, Canada: Toronto Department of Labour.

Svenson, O. 1978. Risks of road transportation in a psychological perspective. *Accident Analysis and Prevention* 10:267-280.

Swanson, J. A., M. I. Sachs, K. A. Dahlgren and S. J. Tinguely. 1987. Accidental farm injuries in children. *American Journal of Diseases of Children* 141:1276-1279.

Teplow, L. 1987. *Regulating Safety and Health: A Working Model*. Des Plaines, IL: American Society of Safety Engineers.

Tesser, A., D. R. Shaffer. 1990. Attitudes and attitude change. *Annual Review of Psychology* 41:479-523.

Tevis, C. and C. Finck. 1989. We kill too many farm kids. *Succesful Farming* 87(3):18A-18P.

Thorndike, E. L. 1898. Animal intelligence: An experimental study of the associative process in animals. *Psychological Review* 8.

Thurstone, L. L. 1931. The measurement of attitudes. *Journal of Abnormal and Social Psychology* 26:249-269.

Tormoehlen, R. L. 1986. Fatal farm accidents occurring to Wisconsin children, 1970-1984. ASAE Paper No. 86-5514. St. Joseph, MI: ASAE.

Triandis, H. 1979. Values, attitudes, and interpersonal behavior. In *Nebraska Symposium on Motivation*, eds. H. E. Howe and M. M. Page, 195-259. University of Nebraska Press: Lincoln.

U. S. Bureau of Census, U.S. Department of Agriculture. 1987. Farm population of the United States: 1986. Current Population Reports, Series P-27, No. 60. Washington DC: GPO.

U. S. Office of Management and Budget. 1987. Standard Industrial Classification Manual. Washington, DC: GPO.

Vilardo, F. J. 1988. The role of the epidemilogy model in injury control. *Journal of Safety Research* 19:1-4.

von Neumann, J. and O. Morgenstern. 1947. *Theory of Games and Economic Behavior*, 2nd Ed. Princeton, NJ: Princeton University Press.

Vroom, V. 1964. *Work and Motivation*. New York: Wiley.

Waller, J. A. 1989. Injury control in perspective. *American Journal of Public Health* 79(3):272-273.

Waller, J. A. 1985. *Injury Control: A Guide to the Causes and Prevention of Trauma*. Lexington, MA: Lexington Books.

Walster, E. A., E. Aronson and D. Abrahams. 1966. On increasing the persuasiveness of a low-prestige communicator. *Journal of Experimental Social Psychology* 2:325-342.

Weigel, R. R. 1982. Supporting today's farm family: An opportunity for family life education. In *Family Strength Four: Positive Support Systems*, eds. N. Stinett et al. University of Nebraska Press: Lincoln.

Weinstein, N. D. 1989. Optimistic biases about personal risks. *Science* 246:1232-1233.

Weinstein, N. D., P. D. Grubb and J. S. Vautier. 1986. Increasing automobile seat belt use: An intervention emphasizing risk susceptibility. *Journal of Applied Psychology* 71:285-290.

Wilkerson, I. 26 September 1988. Farms, deadliest workplace, taking lives of children. *New York Times*, A1, A21.

Williams, D. L. 1983. Iowa's farm people and characteristics and agricultural accident occurrence. Unpublished Ph.D. diss. Iowa State University, Ames.

Winn, B. 1983. Processing and interpreting spatial information represented graphically. Paper presented at the annual meeting of the American Educational Research Association. Montreal, Quebec, April 11-15.

Wogalter, M. S., D. R. Desaulniers and J. W. Brelsford, Jr. 1987. Consumer products: How are the hazards perceived? Paper presented at the Human Factors Society 31st Annual Meeting, 615-619.

Wolgater, M. S., N. A. McKenna and S. T. Allison. 1988. Warning compliance: Behavioral effects of cost and consensus. Paper presented at the Human Factors Society 32nd Annual Meeting, 901-904.

Wood, W. and A. M. Eagly. 1981. Stages in the analysis of persuasive messages: The role of causal attributions and message comprehension. *Journal of Personality and Social Psychology* 40:246-259.

Zimbardo, P. G. 1960. Involvement and communication discrepancy as determinants of opinion conformity. *Journal of Abnormal and Social Psychology* 60(1):86-94.

Zink, W. L. 1930. Standarization of the power-take-off for farm tractors. *Agricultural Engineering* magazine 11(2):75-79.

Appendix A

Ten Strategies for Reducing These Losses

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(The following is taken from Technology Review: 72(2), 1970)

Several strategies, in one mix or another, are available for reducing the human and economic losses that make this class of phenomena of social concern. In their logical sequence, they are as follows:

The **first** strategy is to prevent the marshalling of the form of energy in the first place: preventing the generation of thermal, kinetic, or electrical energy, or ionizing radiation; the manufacture of gunpowder; the concentration of U-235; the build-up of hurricanes, tornadoes, or tectonic stresses; the accumulation of snow where avalanches are possible; the elevating of skiers; the raising of babies above the floor, as to cribs and chairs from which they may fall; the starting and movement of vehicles; and so on, in the richness and variety of ecologic circumstances.

The **second** strategy is to reduce the amount of energy marshalled: reducing the amounts and concentrations of high school chemistry reagents, the size of bombs or firecrackers, the height of divers above swimming pools, or the speed of vehicles.

The **third** strategy is to prevent the release of the energy: preventing the discharge of nuclear devices, armed crossbows, gunpowder, or electricity; the descent of skiers; the fall of elevators; the jumping of would-be suicides; the undermining of cliffs; or the escape of tigers. An Old Testament writer illustrated this strategy in the context both of the architecture of his area and of the moral imperatives of this entire field: "When you build a new house, you shall make a parapet for your roof, that you may not bring the guilt of blood upon your house, if any one fall from it." (Deuteronomy 22:8). This biblical position, incidentally, is fundamentally at variance with that of those who, by conditioned reflex, regard harmful interactions between man and his environment as problems requiring reforming imperfect man rather than suitably modifying his environment.

The **fourth** strategy is to modify the rate or spatial distribution of release of the energy from its source: slowing the burning rate of explosives, reducing the slope of ski trails for beginners, and choosing the reentry speed and trajectory of space capsules. The third strategy is the limiting case of such release reduction, but is identified separately because in the real world it commonly involves substantially different circumstances and tactics.

The **fifth** strategy is to separate, in space or time, the energy being released from the susceptible structure, whether living or inanimate: the evacuation of the Bikini islanders and test personnel, the use of sidewalks and the phasing of pedestrian and vehicular traffic, the elimination of vehicles and their pathways from community areas commonly used by children and adults, the use of lightning rods, and the placing of electric power lines out of reach. This strategy, in a sense also concerned with rate-of-release modification, has as its hallmark the elimination of intersections of energy and susceptible structure—a common and important approach.

The very important sixth strategy uses not separation in time and space but separation by interposition of a material "barrier": the use of electrical and thermal insulation, shoes, safety glasses, shin guards, helmets, shields, armor plate, torpedo nets, antiballistic missiles, lead aprons, buzz-saw guards, and boxing gloves. Note that some "barriers," such as fire nets and other "impact barriers" and ionizing radiation shields, attenuate or lessen but do not totally block the energy from reaching the structure to be protected. This strategy, although also a variety of rate-of-release modification, is separately identified because the tactics involved comprise a large, and usually clearly discrete, category.

The **seventh** strategy, into which the sixth blends, is also very important—to modify appropriately the contact surface, subsurface, or basic structure, as in eliminating, rounding, and softening corners, edges, and points with which people can, and therefore sooner or later do, come in contact. This strategy is widely overlooked in architecture with many minor and serious injuries the result. It is, however, increasingly reflected in automobile design and in such every day measures as making lollipop sticks of cardboard and making some toys less harmful for children in impact.

Despite the still only spotty application of such principles, the two basic requisites, large radius of curvature and softness, have been known since at least about 400 B.C., when the author of the treatise on head injury attributed to Hippocrates wrote: "Of those who are wounded in the parts about the bone, or in the bone itself, by a fall, he who falls from a very high place upon a very hard and blunt object is in most danger of sustaining a fracture and contusion of the bone, and of having it depressed from its natural position; whereas he that falls upon more level ground, and upon a softer object, is likely to suffer less injury in the bone, or it may not be injured at all..." [*On Injuries of the Head*, the Genuine Works of Hippocrates, Trans. F. Adams (The Williams and Wilkins Co., Baltimore, 1939)].

The **eighth** strategy in reducing losses in people and property is to strengthen the structure, living or nonliving, that might otherwise be damaged by the energy transfer. Common tactics, often expensively under-applied, include tougher codes for earthquake, fire, and hurricane resistance, and for ship and motor vehicle impact resistance. The training of athletes and soldiers has a similar purpose, among others, as does the treatment of hemophiliacs to reduce the results of subsequent mechanical insults. A successful therapeutic approach to reduce he osteoporosis of many postmenopausal women would also illustrate this strategy, as would a drug to increase resistance to ionizing radiation in civilian or military experience. (Vaccines, such as those for polio, yellow fever, and smallpox, are analogous strategies in the closely parallel set to reduce losses from infectious agents.)

The **ninth** strategy in loss reduction applies to the damage not prevented by measures under the eight preceding—to move rapidly in detection and evaluation of damage that has occurred or is occurring, and to counter its continuation and extension. The generation of a signal that response is required; the signal's transfer, receipt, and evaluation; the decision and follow-through, are all elements here—whether the issue be an urban fire or wounds on the battlefield or highway. Sprinkler and other suppressor responses, firedoors, MAYDAY and SOS calls, fire alarms, emergency medical care, emergency transport, and related tactics all illustrate this countermeasure strategy. (Such tactics have close parallels in many earlier stages of the sequence discussed here, as, for example, storm and tsunami warnings.)

The **tenth** strategy encompasses all the measures between the emergency period following the damaging energy exchange and the final stabilization of the process after appropriate intermediate and long-term reparative and rehabilitative measures. These may involve return to the pre-event status or stabilization in structurally or functionally altered states.