

RESEARCH FOR AGRICULTURAL SAFETY AND HEALTH

James A. Merchant, M.D., Dr.P.H.
Professor, Preventive and Internal Medicine
Director, Institute of Agricultural Medicine and Occupational Health
The University of Iowa

Mr. Mark Timm: Our next speaker is Dr. James A. Merchant, Director of Agricultural Medicine and Occupational Health at the University of Iowa. Dr. Merchant received his B.S. from Iowa State University, his M.D. from the University of Iowa, and his Doctor of Public Health in epidemiology from the University of North Carolina. In 1968, he became an Epidemic Intelligence Officer at the Centers for Disease Control with an assignment to the North Carolina Board of Health. After this assignment, he served as Assistant Professor in Medicine at the University of North Carolina. In 1975, Dr. Merchant became Director of the Division of Respiratory Disease Studies at NIOSH. In 1981, he became and currently is Professor of Preventive and Internal Medicine at the University of Iowa. Dr. Merchant has published broadly in pulmonary medicine and epidemiology. His early work was in associating cotton dust exposure with byssinosis. He has published broadly on different lung diseases, which include problems with vegetable dusts and other organic dusts in agriculture, farmers' lung, and asthma. Dr. Merchant is active in professional organizations and in chairing and serving on expert committees at both the national and the international levels. Allow me to introduce to you Dr. James Merchant to speak on *Research for Agricultural Safety and Health*. Dr. Merchant:

ABSTRACT

In identifying research priorities for agricultural health and safety, one must first define the populations at risk. In agriculture, those at risk greatly exceed the number of farmers who report sole or primary employment from agriculture. Agricultural production is now changing dynamically, resulting in a substantial increase in farmers with non-farm jobs, greater involvement of women and seasonal workers, and involvement of children and recreational farmers in agricultural operations. All are exposed to some degree to multiple farm hazards—farm machinery, livestock, chemicals, organic dusts, and a wide variety of biological hazards. Priorities for research in agricultural safety and health include disease and injury surveillance; epidemiological investigations of morbidity, mortality and risk factors; studies of toxicological effects and mechanisms of disease; and the opportunity for meaningful intervention for disease and injury prevention. Those engaged in this research must also recognize the influence of poverty, limited access to health care, and limited insurance coverage among many living and working in rural areas. As the result of the national initiative in agricultural and environmental health, federal, state and foundation funding is now available to address these research priorities. The challenge is to maintain and cultivate these research opportunities through targeted research designed to advance our understanding and prevention of diseases and injuries among those with agricultural exposures.

THE POPULATION AT RISK

The population at risk to farming exposures is not known with precision. In 1980, some 2 million Americans reported prima-

ry employment in farming; 3.1 million reported some farm income; there were 2.7 million hired to do farm labor; and there were an additional 6 million farm-family members, some of whom did farm

work. But the number of full-time farmers is being reduced as agriculture moves dynamically to larger numbers of corporate farming operations, with greater numbers of part-time farmers and farmers with off-farm jobs, and more farm wives employed in both farm and off-farm jobs, while significant farm work is contributed by children under the age of 18.

A state-wide survey of Kentucky farms found 26 percent of farm men had off-farm jobs, 15 percent of farm women had off-farm jobs, and 23 percent with both farm men and women holding off-farm jobs.¹ Women's role in agricultural production has been largely ignored in the occupational literature, yet the proportion of women participating in the agricultural workforce has risen steadily from 11 percent in 1940 to 46 percent in 1980.²

In the University of Iowa Farm Family Survey of 1988 that included Iowa, Washington and New York states, 25-40 percent of women (depending on the state) were employed full-time in farming, and 45-55 percent were employed part-time in farming. Only 11-30 percent reported doing no farm work.³ In addition, 3549 percent of the farm women surveyed were employed in off-farm work. Thus, many farm men face two work exposures (farm and off-farm job) while many farm women face three (farm, off-farm job, and home).

In addition to the occupational risks posed by the off-farm jobs, there is a significant additional risk of travel to and from the off-farm job on rural roadways, often under poor driving conditions. As 64 percent of the nation's 48,700 motor vehicle deaths in 1988 occurred in rural areas, travel to and from work poses an additional occupational risk, which has often been

ignored in occupational health and safety research.⁴

There is even less information on the numbers of children at risk to agricultural operations. In the University of Iowa Farm Family Survey, the proportion of farms reporting children regularly doing farm work ranged from 18 percent (New York) to 23 percent (Iowa).³ It is recognized, however, that the number of children at risk to agricultural operations is much larger, as they are often exposed to farm machinery, buildings, and livestock while not engaged in routine farm work.

Migrant farmers are the most fluid population at risk in agriculture. The numbers at risk are not adequately defined, but it is known that migrant farmers assume some of the highest risks from exposure to agricultural chemicals, long hours, and some exposure to agricultural machinery, in addition to poor living conditions, limited—if any—insurance or health care, and often an additional risk of extensive travel over the harvest season.

Migrant farmers are especially challenging to study, as they are highly mobile, have variable exposures, and are a difficult population on which to obtain valid data because of language and legal barriers. Migrant farmers are, nevertheless, a very high priority for research because of their extensive exposures and other risks to health.

An additional population at risk in agriculture is the weekend or recreational farmer who typically farms a few acres using older farm machinery, often has some livestock, and often uses the same farm chemicals as full-time farmers. The number of weekend farmers is not known, but is increasing as

urban areas encroach on adjacent farm land.

Thus, the total population at risk to agricultural exposures is large, but the number is unclear—while the number of full-time farm workers appears to be decreasing, the total population at risk to agricultural operations may not be, given the diversity of multiple work roles of farm men, women, children, and migrant workers. Currently, there is no uniformity in classification of farm men, women, and children in regard to farm work and off-farm work. Clearly, development of such a classification would be useful for assessment of agriculture - related diseases and injuries among those living in rural America.

Therefore, four research priorities are:

1. To determine the distribution of farm men, women, and children and the total population at risk in agriculture.
2. To develop the best standard classification of farm men, women, and children, by on-farm and off-farm employment, that will provide the most relevant classification for health surveillance and epidemiological assessment.
3. To assess what additional occupational morbidity and mortality is attributable to off-farm work and to travel to and from off-farm work, and what the interactive effects of these multiple risks on disease and injury incidence are.
4. To determine, especially among migrant farm workers, what non-farming morbidity and mortality is attributable to living conditions, limited availability of health care delivery, and extended travel and what the interactions of these

factors and the multiple risks they face in agricultural work are.

These questions will be high priorities for the NIOSH Farm Family Health and Hazard Survey and should also be priorities for others engaged in health and injury surveillance and epidemiological studies of agricultural workers.

RESEARCH METHODS

Research approaches to agricultural safety and health may be divided into five broad research methodologies:

1. Basic Research (Toxicology and Mechanisms).
2. Disease and Injury Surveillance (Information Systems).
3. Epidemiological Studies.
4. Demonstration and Education Research (Intervention Studies).
5. Health Services Research.

Basic Research

Basic research is essential for adequate development of prevention strategies for agricultural safety and health. While this is less true for injuries, there is still a great need for basic research on the toxicology and mechanisms by which various agricultural exposures cause adverse health effects.

► One clear need for greater basic research is in the area of toxicological testing of agricultural chemicals, especially older pesticides that have not yet been tested for acute and chronic toxicity. This

is a subset of a larger testing issue faced by the National Toxicology Program.

- At a National Institute of Environmental Health Sciences Conference on Agricultural Chemical Utilization and Human Health, the need for further chemical testing to address organ function, perinatal toxicity, immunotoxicity, and chronic and delayed effects including cancer and delayed nervous system manifestations (and testing of combinations of chemicals) was strongly recommended.

- ▶ A second area where basic research needs to play an important role is in the emerging area of agricultural biotechnology. Genetically engineered microorganisms promise substantial benefits for food production throughout the world.

Potential benefits include new crop varieties that will benefit the grower through lower input costs and increased productivity, the food processor through production of higher-quality and consistent products, and ultimately the consumer through production of more appealing and nutritious foods. Use of biotechnology in agriculture has potentially significant implications for agricultural safety and health.

Two potentially lowered risks that may accrue through use of agricultural biotechnology include:

1. Reduced use or replacement of agricultural chemicals now known to be harmful to human health.
2. Reduced field exposures to crop production, especially to farm machinery, which is known to be the single greatest risk in farming.

Biotechnology is currently being regulated by EPA through the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA; 7 U.S.C. 136-136y) and regulation adopted in 1984 (49 Federal Register 40659), the Toxic Substances Control Act (TSCA; 5 U.S.C. 2601-2929), and by the USDA through provisions of the Plant Pest Act (7 U.S.C. 150aa-jj) and regulations adopted in June of 1987 (CFR Part 330).

- While regulation of this emerging technology provides some assurance that appropriate testing will be done, from a public health perspective it is essential that necessary testing for adverse effects on plants and animals be conducted in the laboratory and in small field experiments.

Experience to date suggests that the use of biotechnology in agriculture will not be associated with unpredictable exposures that cannot be addressed using appropriate work practices.⁵

Disease and Injury Surveillance

The development of disease and injury surveillance or information systems is a very high priority for the advancement of agricultural safety and health research. As surveillance is covered by another speaker, I will confine my comments to those information systems especially important to epidemiological research. These information systems fall in two categories—those dealing with health effects (injuries and diseases) and those dealing with exposures (cohorts with specific exposures or systems defining exposures to which human or animal populations may be linked).

- Information systems that are especially useful in epidemiology are specific disease and injury registries. Often existing cancer registration data is available from state or

hospital data. Use of these information systems is an inexpensive and powerful epidemiologic tool.

Through the State Health Registry of Iowa at the University of Iowa, we are now able to register birth defect and cancer incidence. An Alzheimer's Disease Registry has also been developed for some counties, and a Rural Injury Surveillance System is now under development.

These health effect registries are especially useful as they allow systematic collection of large numbers of specific types of birth defects, cancers, or injuries that can then be studied quantitatively through the use of case control studies. This approach has been used effectively in the assessment of risk factors for a variety of specific types of cancer.

The same approach is now being applied to birth defects, which have an added advantage of having a much shorter latency (hence more accessible and valid data). In the case of injuries, there is no latency and the circumstances of injury are usually clear. This will allow the injury registry to collect more data at the time of the event and thus reduce the time and cost of case control studies.

Epidemiological Studies

- A significant problem in assessment of surveillance and epidemiological data is the lack of adequate exposure data. The development of exposure registries is, therefore, especially attractive.

For instance, large cohorts of pesticide applicators who must be licensed to do their work now provide an especially important opportunity for epidemiological research through record linkage to cancer

and birth defect registries. Data on the sale of certain farm chemicals provide another type of exposure registry. Another type may be derived from widespread testing of drinking water for nitrates and pesticides.

While these exposure registries usually provide evidence of exposure to certain agricultural chemicals, epidemiological research requires much more detail in terms of the types and amounts of specific chemical use, the time-frames of use, the type of application, and the use (and non-use) of protective equipment. These types of data must almost always be collected retrospectively, but could be collected prospectively in a small cohort or in a sample of a larger cohort.

Collection of representative exposure data is also essential in cross-sectional studies of injuries and health effects. These data are necessary in order to derive exposure response relationships, which are essential to the development of guidelines for reduction of exposures and the prevention of diseases and injuries.

- There are very few trained industrial hygienists specializing in agriculture. The need for these skills in the collection and interpretation of environmental data is critical to advance agricultural health and safety research.

Demonstration and Education Research

Closely related to epidemiological research is the area of demonstration and education research that utilizes intervention studies. While epidemiological research may clearly show an excess in a certain type of cancer, birth defect, respiratory disease or specific type of injury, a valid model for

intervention may not be available or may be difficult to implement.

The traditional intervention model in occupational safety and health is that of regulation, which has seen some significant successes, such as the reduction of respiratory disease through the regulation of coal mine dust and cotton dust. Occupational safety and health regulation has, however, been greatly diminished over the past decade, and agriculture has traditionally not been a regulated industry.

If we cannot develop a U.S. model for a proven intervention on the single most important cause of agricultural mortality, how can we succeed in addressing less dramatic yet still important causes of agricultural diseases and injuries?

As a result, more innovative intervention methods for disease and injury prevention are needed in agricultural safety and health. A good example of the need for such a model is the prevention of tractor roll-over deaths through the application of roll-over protective structures (ROPS) on both new and older tractors.

The epidemiological evidence for the very significant risk posed by tractors without ROPS is clear. The data available from Sweden, which mandated such a program, makes it equally clear that ROPS can prevent almost all tractor roll-over deaths.

• An important question for this conference is whether an American intervention model can be developed that can produce a significant reduction of tractor roll-over deaths and injuries. A second question, with much broader ramifications, is, "If we

cannot develop a U.S. model for a proven intervention on the single most important cause of agricultural mortality, how can we succeed in addressing less dramatic yet still important causes of agricultural diseases and injuries?"

Health Services Research

An observation made by Dr. James A. Dosman in his summary of the research workshops prior to the conference, "Agricultural Occupational and Environmental Health: Policy Strategies for the Future," was the following:

It is striking that the organized scientific documentation of specific health risks is occurring at a time when changing rural economic resources and family and rural community infrastructures are leaving few community resources to alter specific risk patterns. Thus, the assessment and presentation of health and family-life deficiencies must be viewed in a climate of economic adjustment, rural population decline, and loss of personal, financial, and social control by individuals and families. However, one must realize that whereas all these changes are occurring simultaneously, unacceptable injury, death, and dysfunction are occurring on the farms and in rural areas. This conundrum describes a widening gap in diagnostic and preventive health services, and in family support services, between rural dwellers and city dwellers.⁶

While this paper is not intended to address the very broad field of health services research, this quotation points out that there are significant differences between rural populations and their urban counterparts, which must be taken into account in conducting epidemiological research. In nearly every parameter of health—disease

and injury incidence, availability of health care, and related social services—people living in rural areas have less favorable statistics than their urban counterparts.⁷ Especially vulnerable are migrant agricultural workers who are at triple jeopardy—poor, rural and uninsured.

- These social service and health-care delivery factors clearly influence the incidence of rural injuries and diseases and point up the importance of interaction and collaboration between those engaged in agricultural health and safety research with rural sociologists and those engaged in rural health care delivery research.

AGRICULTURAL DISEASE AND INJURY RESEARCH PRIORITIES

Injury Morbidity and Mortality

Available data on the risk of injury and traumatic death consistently reflect a higher injury risk to those living in rural compared to urban areas, with a mortality rate for unintentional injuries twice that of urban areas.⁸ This excess is attributable to several factors, including increased mortality from motor and non-motor vehicle deaths arising from higher speeds on poorer roads, less seat belt use, more use of high-risk utility vehicles, and poorer access to trauma care. At particular risk to rural injury are farmers, their family members, and hired and migrant laborers.

In addition to the several factors that place rural residents at increased risk are added the occupational risks of farming. The National Safety Council estimated deaths among farm residents to be 56.2 per 100,000, 30.1 of which were motor-vehicle-related, 20.1 work-related (18.1 in farm work), 8.0 home-related, and 4.0 public non-motor vehicle deaths.⁴ The trend in

agricultural mortality over the past ten years has shown relatively little improvement and remains higher than that of mining and construction.

NIOSH, through its National Traumatic Occupational Fatalities (NTOF) database, reports 20.7 deaths per 100,000 agricultural workers, versus 7.9 deaths per 100,000 for the general private - sector workforce.⁹ Results of epidemiological studies and newly developed surveillance systems suggest these national estimates may significantly underestimate both deaths and farm-related injuries.

The Iowa Department of Public Health farm injury surveillance program (SPRAINS) reported 83 deaths for 1990 based on voluntary reports from health-care providers.¹⁰ As this was the initial year of reporting, it is thought that this number is incomplete; yet this number of deaths is over 60 percent higher than previous estimates of farm deaths in Iowa. Epidemiological studies draw our attention to the importance of farm machinery in fatalities and severe injuries, to higher rates of injury among children and the aged, and to the substantial numbers of intentional deaths (suicides and homicides).¹¹

While it is clear that traumatic injuries and deaths are epidemic on American farms, we still lack national and state-based information systems (surveillance), a reasonable understanding of risk factors, and an adequate characterization of hazards of farming associated with injury morbidity and mortality. Therefore, three research priorities in the area of traumatic injuries are:

1. Development of national and state-based information systems, which will

Questions to Guide the National Agenda

provide essential injury and injury mortality incidence data by type of injury (ICD-9 codes), cause of injury (E-codes), place of injury and demographic information on the injured party.

2. From surveillance data or large epidemiological studies, case control studies of specific farm injuries, which will allow much better understanding of risk factors associated with the injury.
3. A much better environmental assessment of farm machinery, farm buildings, livestock operations, on and off-road vehicles, agricultural chemical use and storage, and available prevention measures. This assessment is essential to epidemiological surveys and case-control studies

Respiratory Health Effects

Farmers and other agricultural workers are exposed to a number of respiratory hazards, the most common of which is organic dust. Additional exposures, which are known to be important include several agricultural chemicals, toxic gases from livestock confinement facilities, toxic and immunogenic constituents of microorganisms, feed additives such as antibiotics, and infestations of insects, which may produce lung disease.^{12, 13}

A common denominator in these exposures is a significant exposure to organic dust, which has been shown by many epidemiological studies to result in acute symptoms of airway inflammation, heightened airway reactivity and asthma, and acute changes in lung function. Pulmonary edema followed by bronchiolitis obliterans and hypersensitivity pneumonitis are relatively uncommon but well-known pulmonary conditions arising from certain agricultural exposures.

In some agricultural populations with long exposure to organic dust, fixed airway obstruction has been observed. Despite recent interest in this area, there are significant research gaps including the following:

1. There is little surveillance data and incomplete epidemiological data on respiratory diseases in several agricultural populations. Disease patterns and risk factors are still incompletely understood in the animal confinement and grain handling and processing industries, and from exposures to agricultural chemicals such as anhydrous ammonia.
2. There is a very great need for the development of dose-response data for agricultural exposures in order to allow fuller development of prevention strategies.
3. There is a need to more fully explore certain environmental factors, such as exposure to storage mites and the toxic products of certain microorganisms, in both the laboratory and through field studies.

Cancer

Epidemiological studies reported a decade ago initially raised questions about an association between soft-tissue sarcoma and lymphoma and exposure to acetic acid herbicides and chlorophenols. Since then, over 20 additional cohort and case-control studies have addressed this issue. The results of these studies are not consistent, but excess deaths from non-Hodgkin's lymphoma, multiple myeloma and leukemia have shown more consistent positive associations.

In addition, excesses of lung, stomach and prostate cancer have been observed in cohort studies of manufactures and applicators.¹⁴ Other potential risk factors for cancer incidence include viruses, and dietary and other factors as possible contributors to cancer incidence among agricultural workers.¹⁵ A number of methodological issues pose difficulties in interpreting these findings and indicate priorities for research in this area:

1. There is a uniform need for better environmental characterization of agricultural chemical exposures through the development of valid and inexpensive environmental exposure protocols.
2. Use of exposure registries linked with cancer registries promises to provide important additional data on cancer risk among agricultural workers.
3. Improved epidemiological methods to assess and validate previous agricultural and other exposures are needed for adequate analysis and evaluation of cancer data.

Reproductive Health Effects

Concern about possible adverse reproductive health effects arises from toxicological testing showing some agricultural chemicals to be teratogenic, from widespread use of some of these chemicals, and from some case reports suggesting associations between certain adverse reproductive effects and agricultural exposures.^{16,17} The reports on dibromochloropropane (DBCP) on male reproductive function have provided an important example of the toxic effects of this pesticide, an exposure, which now continues in some developing countries.¹⁸

Assessment of adverse reproductive effects has a significant methodological advantage over assessment of cancer incidence in that the latency from the time of exposure to the time of the reproductive effect is much shorter than that for cancer, which is generally 20 or more years. The lack of birth defect information systems has greatly hampered evaluation of birth defects in association with environmental exposures. Priorities for research in this area fall in two areas:

1. Additional systematic toxicological testing of agricultural chemicals and commonly used combinations of chemicals for adverse reproductive effects.
2. Further development of birth defect registries and linkage of these information systems with exposure registries, and through the development of case-control studies with adequate exposure data.

Neurological Health Effects

Recent reviews of the neurotoxic effects of pesticide exposure have focused on chronic neuropsychological sequelae from exposures to organophosphate pesticides.^{19,20} While the early (immediate and delayed) neurotoxic effects are well-described for organophosphate intoxication, until recently little attention had been given to evaluation of possible chronic effects.

However, as the result of several case studies and clusters of adverse behavioral and neurological findings, the World Health Organization (WHO) and the United Nations Development Programme (UNDP) are coordinating a ten-country European, prospective epidemiological study on the neurotoxic effects of low-level exposure to organophosphorus pesticides.

Questions to Guide the National Agenda

This study includes both pesticide formulators and agricultural workers. Additional studies of three types are needed:

1. A replicate of the European study through the use of recently developed and standardized tests of neuro-psychological function and extensive characterization of exposures to organophosphate pesticides;
2. Well-controlled follow-up studies of workers who have documented cases of acute organophosphate intoxication for possible chronic neuropsychological effects; and
3. Greater attention to neurotoxic effects of agricultural chemicals through toxicological testing.

Repetitive Trauma

Trauma research in agricultural populations has focused almost entirely on acute traumatic injury and death. Yet repetitive trauma is known to be a much more significant problem than acute trauma in most industries.

There is reason to suspect that significant repetitive trauma may occur as the result of vibration and repetitive tasks in the use of farm machinery and other farming operations. A recent case-control study of hip joint arthrosis among Swedish farmers found a relative risk for this condition between 2.1 and 3.2, varying by length of time in farming.²¹

There is also reason to believe that long hours of work on agricultural machinery may induce significant muscle fatigue, which may, in turn, contribute to the risk to acute injury. Repetitive trauma has not been systematically studied among farming

populations, but should be a research priority:

1. Surveys of farming populations to assess acute injuries or other health effects should also include assessment of repetitive trauma conditions, especially those involving the back, hip and knee.
2. Collaboration between agricultural engineers and biomechanical engineers should focus on ergonomic factors that may contribute to repetitive injuries and how these factors may be mitigated.

Dermatitis

Dermatitis is a condition endemic in farming. Data from the Bureau of Labor Statistics (BLS) indicate a five-fold greater incidence of dermatitis among farm workers compared to workers in general industry. Because of the limitations in BLS data for agricultural workers, these findings may represent a significant underestimation of dermatitis in this working population. A recent survey of California grape and tomato workers found a high cumulative incidence of dermatitis, suggesting that dermatitis is a frequent and recurrent problem among these farm workers.²²

1. There is a need for systematic dermatological surveys of farm workers with attention given to criteria for classification of dermatological conditions, to the sensitivity and specificity of questionnaires, and to the correlation between questionnaire and exam results.
2. There is a great need for environmental evaluation and measurement of dermatological irritants and sensitizers.

3. Development and evaluation of intervention programs to prevent dermatitis among farm workers are further research needs.

Noise-Induced Hearing Loss

Several studies have now reported bilateral high-frequency hearing loss to be quite prevalent among farmers.²³ Of particular concern is the frequency with which this abnormality is observed among farmers under the age of 30. This strongly suggests that noise is the cause of this injury. Indeed, farm machinery and chain saws are known to generate noise levels above recommended limits. A further finding has been that relatively few farmers use hearing protection. Therefore, research priorities here include:

1. Systematic industrial hygiene surveys to characterize farming operations where noise levels exceed recommended levels.
2. Development and evaluation of intervention programs to provide adequate hearing protection to those engaged in these farming operations.

THE NATIONAL AGRICULTURAL AND ENVIRONMENTAL HEALTH INITIATIVE

Since the publication of *Agriculture At Risk: A Report to the Nation*, which summarized the recommendations arising from the national public policy conference, "Agricultural Occupational and Environmental Health: Policy Strategies for the Future," and the dissemination activities of the NCASH, there is a new level of awareness of the magnitude and severity of disease and injury among American agricultural workers. Significant credit for initiation of and support for this effort is due to several

agricultural industries and foundations, to the interest and support of several state and federal agencies, to the efforts of the National Rural Health Association, to the work of many university faculty who participated in the conferences and briefings, and to the commitment of many members of the U.S. Congress and several state legislatures.

As a result, and for the first time, a healthy dialogue has involved all parties to these important issues. Significant resources are now available through federal appropriations and some state appropriations to mount this national research and intervention initiative. This research effort is just beginning. The challenge ahead is to maintain this momentum and build upon these gains.

CONCLUSIONS

1. The high risk of disease and injury arising from agricultural exposures has now been recognized and has now been placed on the national public health agenda.
2. Adequate resources and incentives have been provided to address the multiple research priorities. These resources must be maintained and cultivated.
3. A healthy dialogue has promoted the involvement of most parties. Greater efforts are needed to involve full representation of children, women, migrants, and the rural poor.
4. The challenge ahead is to prioritize, implement, and publish research findings and translate this research into meaningful prevention and health delivery programs. □

Questions to Guide the National Agenda

REFERENCES

1. Coughenour CM and Swanson L. Work Statuses and Occupations of Men and Women in Farm Families and the Structure of Farms, *Rural Sociology*. 48(1):23-43, 1983.
2. Fassinger PAD and Schwarzseller HK. The Work of Farm Women: A Midwestern Study, *Research in Rural Sociology and Development*. (1):37-60, 1984.
3. Ungar RL. *Farm Women at Risk: Work Roles and Agricultural Exposures*. Thesis, Department of Preventive Medicine and Environmental Health, The University of Iowa, 1990.
4. National Safety Council. *Accident Facts, 1988 Edition*. National Safety Council, Chicago, Ill, 1988.
5. Glass DJ. Agricultural Biotechnology: Occupational Health and Regulatory Issues in *Occupational Medicine: State of the Art Reviews*. 6(2):301-309, 1991.
6. Dosman JA. Technical Workshop Report: Working Group I: Occupational Health and Safety Strategies for Agriculture, *American Journal of Industrial Medicine*. 18:353-356, 1990.
7. Summer L. *Limited Access: Health Care for the Rural Poor*. Center on Budget and Policy Priorities, Washington D.C., 1991.
8. Baker SP, O'Neill B. and Karpf R. *The Injury Fact Book*. Lexington, Mass.: Lexington Books, 1984.
9. Myers JR. National Surveillance of Occupational Fatalities in Agriculture, *American Journal of Industrial Medicine*. 18(2):163-168, 1990.
10. Currier R. Iowa Department of Public Health, Personal Communication, 1991.
11. Stallones L. Surveillance of Fatal and Non-Fatal Farm Injuries in Kentucky, *American Journal of Industrial Medicine*. 18(2):223-234, 1990.
12. Merchant JA. Agricultural Respiratory Diseases, *Seminars in Respiratory Medicine*. Thieme, Inc., No.3, 7:211-224, New York, 1986.
13. Merchant JA. Agricultural Exposures of Organic Dusts. *Occupational Medicine: State of the Art Reviews*. 2(23) April-June:409-425, 1987.
14. Blair A and Zahm SH. Herbicides and Cancer: A Review and Discussion of Methodologic Issues, *Recent Results in Cancer Research*. 120:132-145, 1991.
15. Pearce N and Reif JS. Epidemiologic Studies of Cancer in Agricultural Workers, *American Journal of Industrial Medicine*. 18(2):133-148, 1990.
16. Schwartz DA and LoGerfo JP. Limb Reduction Defects in the Agricultural Setting, *American Journal of Public Health*. 78:654-659, 1988.
17. Gordon JE and Shy CM. Agricultural Chemical Use and Congenital Cleft Lip and/or Palate, *Archives Environmental Health*. 36(5):213-221, 1981.
18. Whorton D. Dibromochloropropane Health Effects, Chapter 48 in *Environmental and Occupational Medicine*. WN Rom (Ed). Little, Brown and Company, Boston, 1983.

19. Rosenstock L, Daniell W, Barnhart S., Schwartz D, and Demers PA. Chronic Neuropsychological Sequelae of Occupational Exposure to Organophosphate Insecticides, *American Journal of Industrial Medicine*. 18(2): 321-326, 1990.
20. Davies JE. Neurotoxic Concerns of Human Pesticide Exposures, *American Journal of Industrial Medicine*. 18(2):327-332, 1990.
21. Thelin A. Hip Joint Arthrosis: An Occupational Disorder Among Farmers, *American Journal of Industrial Medicine*. 18(2):339-344, 1990.
22. Schenker MB and McCurdy SA. Occupational Health Among Migrant and Seasonal Farmworkers: The Specific Case of Dermatitis, *American Journal of Industrial Medicine*. 18(2):345-352, 1990.
23. May JJ, Marvel M, Regan M, Marvel LH, and Pratt DS. Noise-Induced Hearing Loss in Randomly Selected New York Dairy Farmers, *American Journal of Industrial Medicine*. 18(2):333-338, 1990.

INTERVENTION FOR AGRICULTURAL SAFETY AND HEALTH

Myron D. Johnsrud, Ph.D.
Administrator, Extension Service
United States Department of Agriculture

Mr. Mark Timm: From Washington, D.C., our next speaker is Dr. Myron Johnsrud, Administrator of the USDA Extension Service. Dr. Johnsrud holds a master's and doctor's degree in administration from the University of Wisconsin and farmed for a number of years in North Dakota. He directed the North Dakota State University Cooperative Extension Service for 12 years. He served as chairman of the Great Plains Agricultural Council, and served on the Board of Directors of the Prairie Public Television Corporation and on the Board of Trustees of the National 4-H Council. Since 1986, Dr. Johnsrud has directed the U.S. Department of Agriculture's Extension Service. In this position, he is responsible for a \$15 million program and \$370 million of federal allocations to the land grant universities for cooperative extension service programs. He is responsible for a major program for redirecting the Extension Service, in partnership with the Cooperative Extension Service, a national network in the 50 states and territories, and more than 3,100 countries. The redirection focuses on current and critical issues of the nation. Dr. Myron Johnsrud will speak to us this morning on the critical issue of *Intervention for Agricultural Safety and Health*. Dr. Johnsrud:

INTRODUCTION

"The health of the people is really the foundation upon which all their happiness and all their powers as a state depend."

Benjamin Disraeli, prime minister of Britain, made that statement in a speech over 100 years ago, and it is still right to the point today. Safety, too, which we link closely with health, has long been essential to civilization. *Salus populi suprema lex* ("The people's safety is the highest law") was a legal and political maxim of ancient Rome.

The need for surveillance and research to guide injury control efforts in agricultural safety and health presents many challenges that have been identified by the previous speakers. However, we must ask ourselves how society will judge our success in solving the problems of agricultural injuries. I believe that society will judge our success by how effective our intervention methods

are in protecting agricultural workers and helping create the change in their behavior necessary for their success. Intervention countermeasures will rely upon the knowledge gained from research and surveillance programs to implement effective solutions to agricultural health and safety problems.

What makes agricultural production one of the most hazardous occupations in the United States? As we attempt to prevent and reduce the incidence of fatal and serious accidents and chronic illness on our farms and ranches, do we know what areas to focus on for the most success?

How do we keep agricultural safety and health from being overlooked when addressing other issues that confront agriculture, such as the environment, animal welfare, or energy? How wide is our scope—does it stop at the farm gate or timber mill? Or, does it include many segments of food, feed, and fiber processing?

These are just a few of the questions confronting us today in the important issue of agricultural safety and health. This morning I want first to present a brief history and the current status of intervention efforts. Second, I will pose questions to guide the concurrent session on developing intervention strategies for various targeted audiences, approaches to intervention, and the need for collaboration. Third, I will suggest some areas that I see as the pressure points, injuries, and fatalities of highest priority and the places where we have the best chance to intervene successfully.

CURRENT STATUS OF INTERVENTION

Voluntary safety efforts have had much success. Agriculture has the most extensive community of voluntary safety professionals of any industry in the United States. What was probably the first farm safety effort began in 1933, when the Sixth Annual Rock River Valley Safety Conference meeting at Fort Atkinson, Wisconsin organized a farm safety section.

In 1937 the National Safety Council held a meeting of an agricultural section. Its first farm conference took place in 1947. An organized professional effort to prevent farm accidents began in the Cooperative Extension system early in the 1940's with appointment of a full-time Extension farm safety specialist by the University of Wisconsin.

A coalition of farm safety professionals representing agricultural equipment manufacturers, the Farm Bureau, insurance companies, and the Cooperative Extension System chartered the National Institute for Farm Safety in 1961 to provide a forum for the exchange of research results, surveillance data, and effective intervention methods. Much of the success in reducing the

occupational injuries experienced by agriculture over the past 50 years is due to the accomplishments of these professionals working cooperatively through organizations such as the National Institute for Farm Safety and the safety committees and standards committees of the American Society of Agricultural Engineers (ASAE).

We cannot ignore the fact, however, that the rate of decline in agricultural fatalities and injuries is much slower than that experienced by mining and construction, the other two most hazardous industries in this nation. Except for this fact, we would not be here today. Because of it and the efforts of such organizations as NCASH, the Congress has recognized the need to commit additional resources to research, surveillance, education, and intervention programs.

Most of the new programs are being administered by NIOSH. In administering these programs, NIOSH has recognized the value of supporting existing programs. An example of this is NIOSH's intervention program Agricultural Safety and Health Promotion Systems, which is providing funding to enhance educational safety programs through the Cooperative Extension System in 15 states.

Two new NIOSH programs crucial to developing intervention include establishing two new centers in Iowa and California for agricultural research and education and supporting occupational health and safety nurses in agricultural communities. These programs exemplify, too, the key questions we must ask ourselves in developing strategies for intervention programs.

1. How do we implement promising and innovative new programs such as nursing services in agricultural communities

Questions to Guide the National Agenda

so that they complement existing intervention programs?

2. How do we foster programs that utilize the existing infrastructure of organizations, such as the Cooperative Extension System and the National Safety Council, to enhance our ability to make the most effective use of resources available for intervention programs?

What is the current status of safety features on farm equipment? New farm equipment being sold today has the latest state-of-the-art safety technology. When machines are used and maintained properly, injuries and deaths from machinery-related accidents can drop dramatically. ROPS for tractors and tractor seat-belt use could prevent the majority of tractor-related deaths. Virtually all new tractors sold in the United States have ROPS.

Because of the relatively long life of tractors, most agricultural tractors in use do not have ROPS in place. Nearly half of the approximately 400 tractor-related deaths that occur each year in this nation involve rollovers. How do we ensure that the older tractors and machines without these modern safety features get retrofitted with modern safety features when feasible or get taken out of use? The issue of how such updating and retrofitting is practical presents a significant challenge.

I encourage us not to focus solely on tractor fatalities, though they have become a focus of considerable media attention. They account for only a small percentage of nonfatal injuries on farms, compared with traumatic injuries from other causes and chronic occupational illnesses. Engineering and safety standards have long been the primary method of injury control.

Many manufacturers of agricultural equipment rely heavily upon the voluntary standards of ASAE in equipment design when no mandated standards exist. The development and issuance of technical standards by ASAE has contributed strongly to intervention for many years.

New standards and updates related to safety are constantly needed. What intervention programs do we need to ensure that the vast array of small manufacturers of farm equipment are aware of and comply with both mandatory and voluntary standards?

Unlike the situation in many other industries, the autonomy of the agricultural workplace can render many safety standards useless as safety features are discarded or overridden. How will this problem be overcome?

DEVELOPING INTERVENTION STRATEGIES

Characteristics of Target Audiences

How wide a net do we cast for our targets? Do we include forestry and logging? Food, feed, and fiber processing? Textile mills? Workers at fast-food chains? Food safety in general, which means all of us who eat?

As a first level of how wide we cast our net, let us focus on the 3.32 million persons who work on the nation's farms and ranches. Nearly half of these people are self-employed farm operators. The balance are unpaid workers (family), agricultural service employees, and workers hired directly by farm operators.

What methods would work best for reaching farmers? A recent study in New York State found that farmers and farm-

workers, while acknowledging the need for health and safety, did not have time to attend meetings.

Radio, general farm magazines, and conversations with others are prime information sources. The Cooperative Extension Service received a very high rating as a source of health and safety information.

A sizable share of the farm population is children. Accidents are the primary cause of death among children less than 15 years old in the United States as a whole and in farming. About 23,000 farm children are injured on farms each year. Why are these injuries occurring?

Partly, it is the generally risky nature of the farm environment and the fact that it is both home and office for farmers and for their spouses and children. Often, the economic realities of farming create a dependence on children for labor. Frequently, either there is no adequate child care for them off the farm or it is too costly for farm families. These problems exist for both the farm-operator family and the migrant-labor family.

In a recent national survey, farmers reported that they allowed their young children (aged 6-9 years) to ride on a tractor, and as many as 29 percent of 7-9 year-olds were driving the tractor. Between ages 7 and 15, farm children were performing a wide range of farm operations with tractors.

When asked about risks of such behavior, farm parents surveyed saw a low accident-risk level for their children when they were riding on a tractor the parent was operating or when the children were operating the tractor. As great as a 40 percent reduction in the farm fatalities to children

may be possible if children do not ride on tractors.

Studies of the cognitive physical limitations of children at various stages up through 15 years of age indicate that they are being put at risk through farm activities that they are asked to perform.

I have yet to see a farm safety awareness or education program that did not stress the danger of extra riders on tractors. This poses some important questions that need to be applied to all agricultural safety and health problems.

Why are our safety warnings going unheeded? Are we reaching and involving our targeted audiences sufficiently to develop effective education and awareness programs that change behavior? What will be the most effective combination of engineering controls, awareness, education, regulation, and enforcement to find solutions to each problem?

Studies of the cognitive physical limitations of children at various stages up through 15 years of age indicate that they are being put at risk through farm activities that they are asked to perform. Their parents do not understand that risk potential. How do we direct our educational efforts at these target populations? Helping farmers understand the developmental limitations of their children could significantly reduce child accidents and deaths on farms.

Another target population is the estimated 3 million migrant and seasonal farmworkers from many different ethnic groups. Children are about one-third of this population.

No comprehensive baseline health data exist for them. Some of their health problems and hazards are well documented. Others require much more investigation and research. Their need for a wide variety of education and social services is enormous. What are the unique demographic, cultural, and language problems that must be overcome to provide effective intervention programs for this targeted audience?

The average age of U.S. farm operators is 52, with 21 percent of farm operators 65 or older. Farm workers aged 65 and over have two to three times the injury rate of other age groups. Older workers are more vulnerable to injury due to decreases in sensory capabilities (hearing, vision, smell).

They also may be suffering from several chronic occupational illnesses that have high incidence rates among farmers. This target audience offers unique challenges for effective intervention programs that reduce their risk of traumatic injury and prevent increasing the severity of existing health problems.

What intervention programs are needed by audiences who have experienced an injury? Approximately 600,000 farmers have a disability that impedes their ability to perform essential farming tasks. This group is also at high risk to further injury.

Expanding upon several pilot programs, USDA's Extension Service, in cooperation with the National Easter Seal Society and other nonprofit disability organizations, recently launched an innovative program to help farmers with disabilities continue farming.

Extension agents, disability experts, rural professionals, and volunteers will offer

such services as identification and referral of farmers with disabilities, on-the-farm technical assistance for modification of the workplace, and, agriculture-based education to prevent further injury and disability. Accident victims can be a powerful influence in creating behavioral change. How can we more effectively involve these individuals and the grassroots organizations they have created, such as Farm Safety for Just Kids?

Should we target groups that are not employed in agriculture or live on farms but may become victims of farm injuries? What are the risks to individuals that visit or provide services to farms?

Approximately 40 percent of the fatalities that occur in confined-space agricultural accidents are attempted rescuers of farm accident victims. The Cooperative Extension System has trained more than 17,000 professionals in farm accident extrication procedure and nonprofessionals in first-on-the-scene emergency response procedures. These programs are crucial to reducing the risk of injury to the rescuer, reducing the severity of the injury to the victim, and emphasizing the value of injury prevention.

Approaches to Intervention

Various approaches to intervention have been applied to agriculture. What do we know about the effectiveness of injury control strategies in the agricultural workplace? What new method emanating from the public health approach and human factors engineering will be required to solve these problems? How do we educate to achieve behavioral changes toward better agricultural safety and health? Many educational programs are in place.

We have our own, ranging from training of persons who will be using restricted-use pesticides to courses that instruct youth (14-15 years old) in operating tractors safely. Of the more than 23,000 Nebraska youth that have completed the tractor certification training program conducted by the University of Nebraska Cooperative Extension Service, only two have died in tractor-related accidents.

A national strategy could rest on the belief that the most effective preventive efforts will emerge from a process that emphasizes identifying and characterizing problem areas and populations at risk.

How do we educate people to change accident-causing or otherwise risky behavior? Simple identification of a public problem such as agricultural safety and health is not enough to allow the design and development of successful remedial programs.

Building meaningful people-involvement into problem identification, program development, and program delivery is essential. Failure to involve the real stakeholders (the farmers and farmworkers) dooms even the most outstanding programs to failure. The era of unshared decisionmaking is generally behind us.

Need for Collaboration

What is required? The attention, effort, and cooperation of individuals and organizations at every level of society, from this conference to our offices at home. Should there be a national coalition to plan and to coordinate intervention programs? A

national strategy could rest on the belief that the most effective preventive efforts will emerge from a process that emphasizes identifying and characterizing problem areas and populations at risk.

The collaborative efforts of engineers, ergonomists, safety professionals, industrial hygienists, and experts in biomechanics and the behavioral sciences are needed to address the most compelling problem areas by studying what makes up workplace systems and the process, tasks, and tools involved. They must identify potential causal mechanisms, opportunities for intervention, and possible prevention strategies.

How will automatic ("passive") protection be used more in agriculture? Passive protection is generally more effective than "active" measures requiring effort by each worker.

Engineering controls are available for many known hazards but have not been systematically applied and evaluated. "Passive" measures of prevention could involve worker protective-system ventures into the realm of intelligent microenvironments that feature sensors, microprocessors, adaptive protective mechanisms, and display and imaging technology to protect, inform, and warn workers for hazardous conditions at their onset.

How do we ensure that the safety and health of the agricultural worker is not sacrificed for the sake of other issues? In considering common issues, such as selective harvesting versus clearcutting in the forests, we need to be aware that selective harvesting may be better for the environment but that it places the logger at a greater risk of injury than occurs in clearcutting using modern equipment. Can we engineer machines that allow selective

harvesting and that protect the workers using them?

We must apply a systems approach that identifies the multiple benefits and feasibility of intervention methods. For example, closed-container mixing systems for pesticides not only protect the applicator from exposure to pesticides, but can also prevent ground water contamination and reduce the possibility of mixing errors. Communication of multiple benefits can be an effective means of creating a change in behavior.

FUTURE FOCUS

Let us look at success stories in agricultural safety and health. What data do we have on them? We know they exist. Probably one of the greatest shortcomings of existing educational farm-safety programs is the lack of scientific evaluations of their effectiveness. We must conduct more comprehensive evaluations. We need more than simple, generalized descriptors—beyond age and sex of the victim, the time of year of accident, and its severity—for us to develop innovative engineering or educational countermeasures.

Although more research and more data are needed to direct intervention, we know certain health and safety precautions work; ROPS work. Educational programs by the Extension System and others in health, hygiene, and pesticide use all have their successes in reaching our target audiences.

Where do we need to go? We need to focus on injuries that often result in death or severe disability because of their impact on the family and the economic and social costs to society. We need to find workable solutions to tractor fatalities and to reduce and eliminate them, if possible.

Tractor-related injuries are about one-third to one-half of all fatal farm injuries. This figure has changed little in 20 years. We also know that the youth and the aged were involved in a significant portion of total tractor injuries. We need to reach these target groups more effectively.

Injuries that occur with high frequency and may be easily prevented should receive high priority, even if less severe in nature. For occupational illnesses, we can increase educational efforts in the use of common methods of worker protection from hazards and in the use of protective equipment and clothing. Some types of clothing and equipment, for example, can reduce exposure to many harmful agents. We need feasible engineering controls to reduce vibrations, noise exposure, air contaminants, and other harmful agents. We need to stop the decay of basic health services available in rural areas and to reverse this trend.

I have raised many questions for your consideration both now and after you return home. Your presence here today is testimony to the momentum building to address this issue.

I think that we can find the answers to solving these problems through the collaborative efforts of all of you. We can act on measures that we know work now and search for more effective intervention countermeasures. Safety and health are the right of every person involved in agriculture. I wish us success in solving our agricultural health and safety problems.□