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Prevention of Musculoskeletal Disorders for Children and Adolescents Working in Agriculture

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Conference Proceedings:
Prevention of Musculoskeletal Disorders for Children and Adolescents Working in Agriculture

Thomas R. Waters, CPE, Ph.D
Human Factors and Ergonomics Research Section
National Institute for Occupational Safety and Health

And

J. R. Wilkins III, BCE, Dr PH
Division of Epidemiology and Biometrics
The Ohio State University School of Public Health

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Applied Research and Technology

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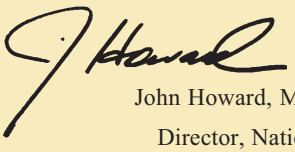
DHHS (NIOSH) Publication No. 2004-119
June 2004

Foreword

Estimates indicate that more than 2 million youths under age 20 live or work on farms or ranches in the United States. Many of these young people perform physically demanding work, such as heavy lifting, pushing, pulling, and carrying of objects. Such tasks may place them at high risk of developing work-related musculoskeletal disorders (WMSDs) such as a carpal tunnel syndrome, low-back disorders, and shoulder and leg injuries. The National Institute for Occupational Safety and Health (NIOSH) considers workplace safety for youths who work in agriculture a high priority research area, and have placed a special emphasis on prevention of WMSDs. The extent of the short- and long-term risks of musculoskeletal disorders resulting from exposure to heavy physical labor for youths who work in these demanding jobs is unknown. Moreover, no surveillance systems are in place to track the magnitude of the potential problem for young workers, and no injury and illness statistics are available for WMSDs for youth and adolescents who work in agriculture. Therefore, it is not possible to determine the magnitude of the health problem. However, a recent study conducted by NIOSH and The Ohio State University has suggested that the physical demands for young workers who perform routine farm chores, such as lifting bales of hay or straw, lifting and carrying bags of feed and water, and other similar tasks are equivalent to those for high-risk jobs performed by adults in the industrial sector.

This document summarizes the discussions of a national panel of experts who were brought together to discuss research needs regarding prevention of WMSDs for youths and adolescents who work in agriculture. The document contains a series of suggestions from the panel participants that identifies the most important research gaps that should be evaluated in the near future. Our hope is that this document will become the blueprint for a national research agenda focusing on prevention of WMSDs for young workers in agriculture over the next decade.



John Howard, M.D.
Director, National Institute for
Occupational Safety & Health,
Centers for Disease Control & Prevention

Acknowledgments

The following NIOSH staff facilitated the breakout groups: Cherie Estill, Stephen Brightwell, Dwight Werren, and Bob Leeka. Stephen Brightwell provided overall assistance in planning and organizing the meeting.

Robert Dick, Division of Applied Research and Technology, and Laura Boyle and her staff in the Office of the Director assisted with the development and editing of the document. Tanya Headley assisted with final editing. Kimberly Clough Thomas provided the cover design, graphics, layout, and photographs for the document.

Contents

Executive Summary

Agriculture is one of the few industries in which children and adolescents are considered an integral component of the workforce. They perform physically demanding jobs that are typically designed for adults. These tasks include lifting and moving materials and equipment, operating farm equipment, and performing jobs requiring moderate to high levels of strength and coordination. There is evidence that work-related musculoskeletal disorders (WMSDs), such as low back problems, cumulative trauma disorders, disability, and lost work time, represent a significant health problem for adults who work in agriculture. However, little is known about the risk of WMSDs for children and adolescents who do similar work. Few studies have evaluated the physical demands associated with jobs performed by children and adolescents and even fewer studies have examined the magnitude and severity of risks that these jobs represent for young workers. Moreover, there are no surveillance systems in place to monitor and evaluate the magnitude of risk for this younger population. In addition, scientific information about the potential long-term risk of adulthood chronic health problems, such as musculoskeletal disorders, as well as effective interventions for younger workers to prevent long-term chronic health problems are lacking.

The purpose of this document is to provide a summary of a national conference that was held in Cincinnati, Ohio, May 6-7, 2002. The conference, co-sponsored by the National Institute for Occupational Safety and Health and the Great Lakes Center for Agricultural Safety and Health at Ohio State University, brought together national experts from across the United States to discuss research needs regarding prevention of WMSDs for children and adolescents working in agriculture. The agricultural safety and health experts who attended the meeting identified specific topic areas regarding WMSDs among children and adolescents working in agriculture for which little or no research exists. The research areas explored at the meeting included: (1) identification of potentially high risk jobs; (2) quantification of the level of risk for jobs performed by children and adolescents in agriculture;

(3) development, evaluation, and implementation of surveillance systems for measuring and tracking the magnitude of health effects and risks for children and adolescents working in agriculture; and (4) development and evaluation of ergonomic interventions for reducing risk of WMSDs for children and adolescents working in agriculture. It should be noted that this meeting specifically excluded injuries attributed to traumatic events, such as cuts, abrasions, lacerations, and injuries associated with instantaneous events, such as slips, trips, falls, and being struck by objects.

The most important suggestions identified by the attendees for future research on WMSDs for children and adolescents working in agriculture are summarized below:

Suggestions for Assessing High Risk Jobs

1. **Develop an "Enterprise Classification" system and evaluate risk of WMSDs based on this classification (e.g., determine risk by region, agriculture sector, or size of enterprise).**
2. **Determine the number of exposed youth and what jobs they are doing in each commodity area.**
3. **Evaluate risk in un-mechanized production (e.g., tool usage in manual labor).**
4. **Identify the hazards or physical work factors in each job or task and determine the number of hours worked per year.**
5. **Evaluate the effectiveness of different methods of risk assessment, including self-assessment, professional judgment, and objective quantitative methods. Use "health outcome" or "level of exposure" as a measure of risk.**

Suggestions for Surveillance Research

1. Develop a national registry of musculoskeletal hazards and health outcomes.

2. Supplement existing surveillance systems (e.g., NHIS, NHANES, BRFSS, California Department of Health, and prospective community-based surveys such as Keokuk and Iowa Safe Farm).

3. Conduct *ad hoc* population-based health and hazard surveys (e.g. clinic- or school-based methods or face-to-face interviews).

4. Develop partnerships with individuals or agencies that interact regularly with children and adolescents working in agricultural settings.

5. Conduct cross-sectional and longitudinal studies to develop and validate a list of high risk jobs and significant health outcomes.

Suggestions for Intervention Research

1. Develop private industry, academic-industry and state agency partnerships. For example, a vocational agriculture awards program for interventions at the high school or college level.

2. Develop improved methods for disseminating information.

3. Conduct studies that address legal, cultural, ethical, and economic barriers to implementing interventions.

4. Encourage more high quality intervention evaluations using randomized trials, quasi-experimental studies, and blended evaluations.

5. Investigate use of existing or modified models for increasing adoption of interventions based on similar successful models, such as the NIOSH hazard control hierarchy model for injury prevention or the tobacco risk awareness model.

Suggestions for Etiological Research

1. Conduct studies to assess physical, cognitive, and developmental capabilities of children/adolescents.

2. Conduct studies to determine the magnitude of exposures and symptoms for children/adolescents in agriculture, including examination of multiple exposures (e.g., sports, second job).

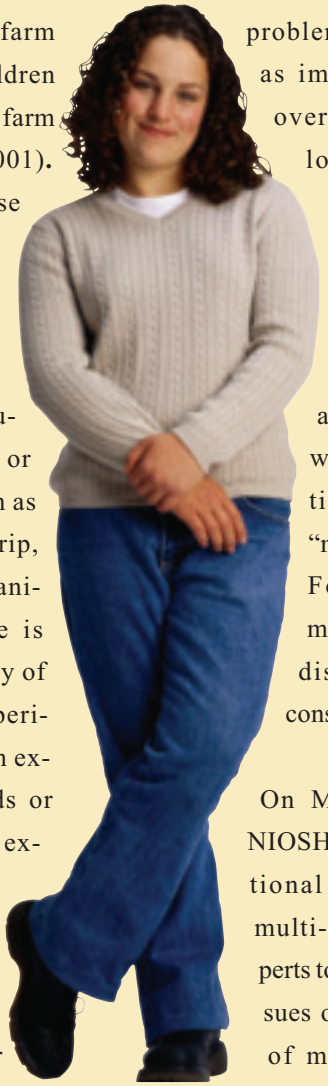
3. Develop and evaluate improved methods for measuring exposure, health outcomes, and other etiological factors.

4. Conduct population, clinical, and laboratory studies to evaluate the short-term impact of risk factors on WMSDs, such as effects of different types of exposures on MSD risk and early indicators, such as biomarkers, bone density, stiffness, and pain.

5. Conduct population, clinical, and laboratory studies to evaluate the long-term impact of repeated exposure. Examples include studies to compare health status of retired farmers compared with non-farm workers and evaluations of the permanent effects of physical loading (studies should include groups with maximal exposures).

Background

In the United States, it has been estimated that more than 2 million youths under age 20 are exposed to agricultural hazards each year, either as farm residents, farm family workers, hired workers, children of migrant or seasonal workers, or farm visitors (Meyers and Hendricks, 2001). In 1998, more than 32,800 of these youths suffered a serious injury or fatality as a result of exposure to farm/agricultural work hazards (Meyers and Hendricks, 2001). In many cases, these injuries resulted from an accident[1] or another instantaneous event, such as a motor vehicle incident, slip, trip, fall, or being struck or hit by an animal or another object. Little is known, however, about how many of the exposed youth may have experienced a WMSD that resulted from excessive physical work demands or from repetitive or forceful muscle exertions, rather than from an accidental event. Generally, WMSDs will involve pain and discomfort in the low back, neck, hands, wrists, arms, shoulders, or legs and can interfere with activities of daily living. Conceivably, these work-related health problems may be just as important for the overall current and long-term health of youths as the more dramatic accidental injuries such as fractures, lacerations, amputations, etc., which are sometimes labeled as "musculoskeletal." For this document, these acute disorders are not considered WMSDs.



On May 6-7, 2002, NIOSH convened a national conference of multi-disciplinary experts to deliberate the issues of the prevention of musculoskeletal

disorders for children/adolescents working in agriculture. The conference provided the first opportunity for health and safety specialists and researchers to meet and discuss risk factors for youth and ways to reduce risk of musculoskeletal disorders in these children/adolescents. The purpose of the conference was to (1) identify jobs performed by children/adolescents in the agricultural industry that pose a significant risk of WMSDs; (2) identify interventions that would be useful in reducing the risk of WMSDs for children/adolescents working in agriculture; (3) identify and discuss potential surveillance methods and issues; and (4) develop a list of research gaps. This report provides a summary of the findings from the two-day meeting. For the purposes of the meeting, WMSD disorder was defined as a work-related health condition or disorder that involves the muscles, nerves, ligaments, tendons, joints, cartilage, spinal discs, and other supporting structures of the body, but is not the result of an accidental event, such as a slip, trip, fall, or being struck by an animal or an object, motor vehicle incident, or other similar event (NIOSH, 1997).

[1] Some attendees objected to the use of the term "accident" for this document, however, for clarity purposes, the first author elected to use the term to refer to any event that would normally be considered an accident by the broad majority of readers.

Key Terms

Agriculture, farm labor, special populations, youth, adolescents, child labor, etiology, high risk jobs, injury, interventions, musculoskeletal disorders, WMSDs, occupation, work hours, research, surveillance.

Overview

In order to set the stage for the deliberations, Dr. David Parker, Park Nicollet Clinic, delivered a presentation delineating the scope of the problem. Using surveillance data compiled from rural Minnesota high schools (Parker et al., 2002; Munshi et al., 2002), Dr. Parker pointed out that both national and regional data indicate that work-related injuries remain a serious ongoing problem for teens in the U.S., as seen in the following statistics:

Farming has been consistently identified as Minnesota's most hazardous occupation. The Minnesota Fatality Assessment and Control Evaluation (MN FACE) program has documented serious ongoing injury hazards associated with tractor use (Brown et al., 1997), augers (Boyle et al., 1995), grain bins (Boyle et al., 1996), and manure pits (Madery and Parker, 1993). In Minnesota, farm work has also been consistently related to child injury-related deaths (Parker and Wahl, 1999). In addition, construction consistently ranks as one of the occupations with the highest rate of both fatal and non-fatal injuries.

The estimated annual incidence of non-fatal injuries among working adolescents in all occupations, including agriculture, ranges from 1.9/100 full-time workers to 16/100 full-time workers (Wegman and Davis, 1999; Layne et al., 1994; Brooks et al., 1993; Brooks and Davis, 1996; Schober et al., 1988).

The estimated incidence of work-related fatalities for adolescents in all occupations ranges from 3.5/100,000 to 5.1/100,000 full-time workers (Castillo and Malit, 1997; Castillo et al., 1994).

The estimated injury rate of full-time agricultural workers ages 14-17 is 4.3/100 (Layne et al., 1994).

Other estimates of farm-related non-fatal injuries range from 1717/100,000 to 1827/100,000 child farm residents (Rivara, 1997; Stueland et al., 1996).

The estimated frequency of occurrence of agricultural fatalities among working youth ranges from 2.3/100,000 to 30.9/100,000 child farm residents, depending on the age and sex group (Stallones and Gunderson, 1994; Rivara, 1997).

Dr. Parker presented findings from two papers that analyzed two data sets involving working farm youth, both funded by NIOSH: (1) "*Causes, Nature, and Outcomes of Work-related Injuries to Adolescents Working at Farm and Non-farm Jobs in Rural Minnesota,"* and (2) "*Adolescent Work Patterns and Work-related Injury Incidence in Rural Minnesota.*"

Although there are many studies on working adolescents, information on youth who simultaneously hold jobs on both a farm and in other sectors of the economy is missing. In the first study, six high schools in rural Minnesota were evaluated for adolescent work practices and injury incidence using a 20-page self-administered survey. A total of 2,250 students completed the survey, representing 92% of the student body. The findings indicated that students who simultaneously hold both a farm and a non-farm job have a significantly higher proportion of injuries than those who work only on the farm or only in a non-farm job. One of the most common types of injuries for youth who worked on a farm was a strain or sprain injury. The investigators concluded that many rural students were employed simultaneously on farm and non-farm jobs, and that students who work

long hours are at significant risk of work-related injury. Although there have been studies on youth work in the U.S., these investigators knew of none that provided a broad picture of adolescent work practices in a rural community.

In the second study analysis, 28% of the 2,250 students who completed the questionnaire lived on a farm. Approximately 45% of the male students were involved in farm work, but only slightly more than 21% of the females reported doing farm work. During the 8-month study period, 2.6% of students were injured while engaged in farm-related activities, and another 5.1% of the students were injured while performing non-farm work.

Many students reported working long hours. The self-reports of 466 students who reported working both a farm and a non-farm job showed 21% working more than 18 hours per week and 5.1% working more than 40 hours per week. In the summer, 44% reported working more than 18 hours per week and more than 20% reported working greater than 40 hours per week during the school year. Some students reported working as much as 60 hours per week.

Based on the findings of both studies, it was concluded that many rural students work long hours and are at significant risk of experiencing work-related injury in a variety of jobs on and off of the farm. Work hours increase substantially when rural youth obtain their driver's license. Students in rural communities report being exposed to a variety of farm hazards that are known to place them at risk of serious injury.

Dr. Parker also discussed the risks faced by youth working long hours. Long work hours may result in more absence from

school, less time doing homework, lower academic performance, and the potential for increased substance abuse (Steel, 1991, Kablaoui and Pautler, 1991; Finch and Mortimer, 1985; Lillydahl, 1990). The adverse impact of prolonged work on academic performance is not surprising. It is reasonable to anticipate that teachers will reward students who spend time studying (Lillydahl, 1990; Mortimer and Finch, 1986). Mortimer and Finch (1986) note that education, occupation, and future socioeconomic attainment are closely linked.

On top of the problems posed by work-related injuries and long work hours, youth also face risks to environmental exposures. For example, previous research has shown that lead has a significantly greater impact on the development of young children than it does on the adult neurological system. While there are no data on the impact of repetitive trauma on early development, Dr. Parker showed several photographs of young children who had developed premature osteoarthritis as a result of carpet weaving during their early childhood.

Finally, Dr. Parker discussed silicosis to illustrate the impact of early exposure on the development of latent onset injury and illness. Dose response relationships between the level of exposure to respirable free silica and the development of silicosis (e.g. chronic fibrosing lung disease) appears to be linear with silicosis developing over time. The health changes that occur with silicosis are most likely if the onset of exposure is at a relatively early age and exposure continues. Even after exposure to silica stops, the disease may progress. Individuals who begin work at an early age are likely to suffer from silicosis at a correspondingly early age.

Meeting Format

Discussion Panels

Following Dr. Parker's overview, the attendees were separated into two panel groups. Both panel groups were asked to deliberate on four basic questions, and to make specific suggestions based on those questions. The questions related to issues of assessment of high risk jobs, surveillance, intervention, and etiology of musculoskeletal disorders for youth working in agriculture. Specifically, the questions and sub-questions were as follows:

1. **What research is needed regarding identification of jobs with high-risk of WMSDs for youth working in agriculture?**

- What jobs do youth perform that pose a significant risk of WMSDs?
- Are exposures similar or different across different environments (e.g., farms, ranches, migrant work)?
- How is risk presently assessed for these jobs? How should risk be assessed in the future?
- What exposure data are needed in order to make recommendations regarding interventions?

2. **What research is needed regarding development and implementation of hazard and health surveillance systems for WMSDs?**

- What surveillance methods have been used for identifying agriculture-related MSDs?
- What surveillance systems would be most effective in tracking agriculture-related MSDs?

3. **What research is needed regarding development and evaluation of interventions for preventing WMSDs for youth working in agriculture?**

- What interventions exist for reducing risk of WMSDs for youth working in agriculture (e.g., engineering controls, administrative controls, personal protective equipment, work guidelines)?

- What interventions are most needed?

- What are the best methods for evaluating the effectiveness of interventions?

- What studies would increase acceptance of interventions, such as the North American Guidelines for Children's Agricultural Tasks (NAGCAT) or other interventions?

4. What research is needed to determine the link between physically demanding work by youth in agriculture and risk of WMSDs?

- What are the short-term health effects (positive or negative) for youth working in agriculture; that is, to what extent do youth suffer from WMSDs, and what is the incidence and severity?

- What are the potential long-term health effects (positive or negative) for youth working in agriculture; that is, to what extent does agriculture work as a youth affect risk for WMSDs in adulthood?

- What studies or study designs would be useful in evaluating the short- or long-term risks of WMSDs for youth working in agriculture?

At the conclusion of the panel breakout sessions, the attendees returned to the main meeting area and developed a list of the five most important issues identified for each of the four questions. At the conclusion of the meeting, the comments of the two panels were combined by question, and the following summary of the discussions was developed from the flip charts and audio records of the discussions.

Summary of Panel Discussions

The panel discussions have been summarized categorically based on the order that the questions were posed.

Assessment of High-Risk Jobs

In discussing identification of jobs with high risk of WMSDs for youth working in agriculture, the panel members agreed there are numerous gaps in knowledge. Not only are the answers not known for children/adolescents, but there appear to be gaps in knowledge regarding adults. What is known about adults comes not from agricultural work in which adults engage, but from many other types of work. Even if there were ample evidence for adults, it is not clear whether adult criteria can be applied safely to children/adolescents. According to the Agency for Toxic Substances and Disease Registry (ATSDR), pound-for-pound, children breathe, drink, and eat more than adults. When taking into consideration the idea that various environmental exposures, medication dosages, and foods may affect children differently than adults, coupled with the fact that children may be exposed during critical development stages, ATSDR and other agencies have begun to focus research and outreach specifically on children's health issues (ERG, 2001; Parker and Bachman, 2002).

In addition, the panel recognized that chil-

dren/adolescents are not, in fact, merely small adults. While some children/adolescents may be of the same stature as adults, developmentally they are different, both physically and psychologically. For example, while the NIOSH lifting equation (Waters et al., 1993) predicts that a maximum of 50 pounds represents the ideal lifting condition for an adult, it is likely that this equation would not be valid for children/adolescents because there is no reliable information on what the physical capabilities are for children of various ages, genders, statures, and developmental stages.

The panel also recognized there is only scant information available on the physical capabilities of children and that jobs with high risk of WMSDs for youth working in agriculture have not been well documented. Concern was expressed that focusing only on specific activities may be daunting given that farm work activities are quite variable depending upon the farm. Moreover, there might be certain exposure variables that are more important in one age group, developmentally and physiologically, than in other age groups. For example, it may not be the 15 times that a child or adolescent performed a specific task, but rather the one time they performed the task during a growth spurt or during plate formation that caused a musculoskeletal problem. Or, it may be the combination of the stress level at school, plus the performance of a specific task over four hours which, when combined with a growth spurt, may push the child/adolescent to reach the threshold level which results in a WMSD.

With these issues in mind, panel members suggested that it may be important to first focus upon the work sector, work type, and size of the work enterprise while considering other factors such as demographic variables (e.g., age, gender, cultural group), work tasks (e.g., duration of the task, repetition rate, manual versus mechanized labor, duration, loads, frequency), maturation (e.g., physiological/ developmental stage), body region (e.g., back, upper extremities), and/or body motion (e.g., bending,

lifting, twisting, throwing, squatting, kneeling, combinations of motions). This could be accomplished by developing an enterprise classification system that would allow researchers to focus on enterprise specific problems, rather than on specific high risk jobs. Initially, perhaps researchers should focus on some type of exposure assessment similar to those which have been done for working adults, such as the National Occupational Exposure Survey (NOES), but attention should be directed to children/adolescents. Having an enterprise classification system could not only help to understand the magnitude of the problem, but also could help to focus the overall effort. This could be accomplished through self-assessments, professional judgment, and/or observational studies.

The panel identified a number of basic questions that initially would need to be answered, such as: (1) What is the size of the workforce?; (2) What is the extent of their total work exposure (e.g., how many hours do they work per year)?; (3) What are the types of jobs and/or tasks they do?; (4) What are the hazards or physical work factors for each of these tasks?; (5) What other factors may contribute to the problem such as play, sports, growth spurt, gender, timing, and nutrition; and (6) How can exposures be reduced (e.g., what interventions are needed)?

Surveillance Issues

A number of concerns were raised regarding surveillance. Of particular concern are reporting issues. Many individuals that work within agricultural settings are likely to be missed in the traditional medical/health reporting systems that use specific medical-based diagnostic codes (e.g., physician's office, private medical clinic, hospital, emergency room, public health center, urgent care clinic). For example, those who do not have health insurance may not present themselves in a medical/health based setting, and some people may use medical practitioners other than physicians or nurse practitioners, such as chiropractors or physical therapists, who are outside the traditional sur-

veillance area. Non-authorized workers, such as migrant workers or non-citizens, may not seek treatment for fear of deportation or imprisonment. Non-reporting for any population may be due to fear of difficulty finding or keeping jobs if the employer discovers that the person has a WMSD. Migrant workers, who move from one farm to another and between states, may pose reporting problems in that they may not report all incidents, reporting may be duplicative, or they may not have an opportunity to visit a clinic given their long work hours. A solution for reaching the migrant population may be to incorporate a reporting system for WMSDs in the migrant health centers and mobile clinics that exist in several states.

One solution to the reporting problem is to broaden the base of reporting health care providers. A clinic-based surveillance system would identify all the potential health care providers, both medical and non-medical, in a region and use a customized reporting system to identify WMSDs. When a child/adolescent goes to a clinic for treatment, clinic-based surveillance could capture information about task(s) being performed, how long the child/adolescent was doing the task, the physical workload of the task, whether they also worked a non-farm job, how many hours they work per week, whether they play any sports, and so on.

To illustrate this concept, Dr. Pamela Kidd described a surveillance study conducted by the University of Kentucky and NIOSH designed to prospectively evaluate the effectiveness of a clinic-based reporting system for identifying WMSDs. Initially, a qualitative exploratory study was conducted, followed by a quantitative-based study. The researchers met with providers to discuss surveillance systems and discussed what would and what would not work with clinic personnel. Researchers also customized the sample forms, and developed a process for indexing cases that came into their clinic, emergency departments, and urgent care centers, and then implemented the system over nine months. In essence, researchers found

that the primary MSDs they saw affected the back, shoulder, and neck. There were no reports of children being seen for WMSDs during this time period. Qualitatively, they went back and interviewed some family members and determined that they were taking their children to chiropractors, who were not included as practitioners in the initial surveillance system. What they found was that the back, shoulder, and neck injuries were the result of tasks requiring heavy workloads (high weights or forces and/or repetitive work). According to the participating clinics, the following factors contributed to under-reporting: (1) The person was not aware that the farm task could be the cause of their injury (e.g., back, shoulder, neck). Interviewees attributed it to their non-farm work job most of the time; (2) The providers were not asking if a farm task could be associated with the injury. Adequate consideration was not given to the etiology of the injury. Most interviewees were simply treated with an anti-inflammatory medication; (3) The terminology used for a WMSD may create problems in identifying what you want to identify. For example, a practitioner might have said, "I don't assess for something like a non-traumatic musculoskeletal disorder which may be work related, but I do ask about carpel tunnel syndrome, cumulative trauma disorders and other MSDs"; (4) Determining work-relatedness for a disorder also may have resulted in underreporting. Differences in terminology and understanding of a work-related disorder was sometimes an issue for the interviewee who would primarily associate some disorders, such as hip, knee, or shoulder pain with arthritis rather than to a work situation; (5) There was great difficulty for both the patient (e.g., interviewee) and the provider in differentiating what exactly contributed to the injury. For example, was the injury related to agricultural work or non-agricultural work? Farmer interviewees themselves would say, "I went to see the occupational health nurse at the factory (or my work) for that problem because I thought it was operating the forklift or something else that was causing it."

Many farmers are either uninsured or, if they are insured, they have high deductibles. They also may be reluctant to report health problems because they fear their premiums will go up. It is much better for them to attribute a health problem to non-farm work, and even providers are sometimes encouraged to attribute problems to non-farm work. The system perpetuates non-reporting. By the time most report, they were suffering from chronic arthritis. Moreover, private family farms are not covered under workers' compensation, though commercial farms may be. This may vary by state, but unless farms employ more than 50 employees, they are not likely to have a good workers' compensation policy.

Although clinic-based surveillance might give a snapshot, currently this type of surveillance is not widespread and also does not have provisions for reporting over a long period of time, which limits effectiveness. A study about how to make clinic-based methods more widespread with reporting over a longer period of time may be needed. If effective clinic-based systems could be developed, there would be a solid longitudinal tracking record because each encounter would be well documented, classified with consistent medical nomenclature (i.e., medical ICD codes), reimbursement and cost ratios, etc. Thus, it could be very effective in describing the magnitude of the problem. Nevertheless, this has not been demonstrated in previous studies to date.

Concern was also expressed that because people tend to present late in the natural history of a disease, only the most severe forms of WMSDs would be tracked by the medical community. The whole range of symptoms, however, would be missed unless reporting began with all types of practitioners. It was suggested that what could be identified in clinics might be the "tip of the iceberg" phenomenon. With that in mind, it was noted that sole reliance on clinic reporting may not suffice and that other methods may be needed, such as active encouragement of self reporting.

The panel recognized that it probably would be more cost effective to add to existing systems rather than to design entirely new systems; developing registries would be useful. Surveillance would provide incidence and prevalence data, but a registry could enroll people with early symptoms of WMSDs and then follow them longitudinally by giving them incentives to stay enrolled so that investigators can track what is happening after that point because of developmental issues in youth. It might be possible, however, to modify/adapt an existing registry to assemble a cohort for follow-up. For example, surveillance data are presently being assembled on asthmatic children and this cohort could be used to collect information about WMSDs. Or, a registry might be created on a state level where mandatory sports physicals are required each year, and children/youth have to be cleared to play sports. Investigators could have the providers conduct a musculoskeletal exam yielding annual data. Data would then be available on an annual basis from a sub-group who live/work on a farm and also play sports. This exam could then be followed by a targeted exposure survey that would link WMSDs and farm work. Concern was expressed that the migrant population would be missed through this route.

A number of possible existing systems were suggested, such as the National Agricultural Statistical Service (NASS), the National Health Interview Survey (NHIS), and the National Agricultural Workers Survey (NAWS). However, it was noted that while NASS will do first mailings, they will not allow a second mailing or permit incentives for a completed questionnaire. Some attendees expressed the belief that outputs from the NASS are not as rigorous as traditional health and hazard research would require. It was the view of the attendees that the best information about the size of the workforce has come from the National Agricultural Work Survey (NAWS). This survey added a supplement on child injury surveillance, considering persons less than 20 years of age.

The NHIS has been used to gather musculoskeletal health information. The NHIS is an ongoing effort, but refined with an over-sampling of more high-risk agricultural groups. Given that only 2% of the working population is in agriculture, there was general agreement that over-sampling is needed. The Behavioral Risk Factor Surveillance System (BRFSS) has been used for traumatic injury, but has not been used for child musculoskeletal disorders. There was a general feeling among panel members that, with the right state advocates, add-on modules could be included in the BRFSS, and that investigators could apply for grants to add questions about WMSDs. This would result in a state-based questionnaire which panel members advocated. It may be possible to add a musculoskeletal module to the Youth Risk Behavior Survey (YRBS). It was pointed out, however, that there may be difficulty in unifying the information or adding anything given that much depends upon how the state sample is drawn.

Clinic- and school-based studies may be fruitful, but gaining access to the target population may be problematic. Again, these are perhaps not very good choices for accessing the migrant population given that many of them do not have telephones, nor do migrant children attend school on a regular basis. The panel agreed that face-to-face interviews are probably best for not only the migrant population, but also other difficult to reach populations such as the Amish.

Concern was expressed that it may be difficult to use some of the national databases for purposes other than their initial design purpose due to the complexity of the sampling strategies, such as the necessity for targeted sampling and over-sampling of certain groups to include minorities and farm family children/adolescents. Furthermore, just because the national databases exist, does not necessarily mean that they would be useful data sources for studies of child/adolescent WMSDs. Interagency cooperation issues such as data exchange formats, confidentiality, and cost would need to be addressed.

Nevertheless, by providing focused information on the child/adolescent WMSD problem, a national database would offer an effective method of measuring the scope of the problem. There are numerous examples of using national reporting systems to gather focused information. For example, by piggybacking on state and national immunization programs, there may be an opportunity presented to also assess the magnitude of WMSD problems. Thus, when a sixth grader must go for required immunizations and enter the health care system he or she could also be evaluated for WMSDs. Since every child must be schooled, it may be possible to conduct studies, such as strength testing, range of motion, and sensory/motor functions (e.g., balance, coordination, hearing, vision) testing through the school system. There may be opportunities to use existing resources to access ad-hoc population-based information, such as youth joining the military or other organized groups.

The panel believed that attention must also be paid to long-term issues. There may be children, for example, who grew up on farms engaging in various tasks, as opposed to those who grew up in urban environments and then go to work on a farm as a teen. It is not known which group is more prone to have long-term musculoskeletal health effects. The panel suggested that a longitudinal study similar to the Framingham study was needed. There are existing NIOSH agriculture related projects which are longitudinal, such as the Keokuk study out of the University of Iowa (Stromquist et al., 1997).

Intervention Issues

The panel agreed that there are very few studies addressing effective interventions in agriculture, and almost none specifically designed to prevent WMSDs in children and adolescents. There is a need for research to evaluate how current interventions used in other occupational settings could be modified or used for tasks that children/adolescents are performing. All workforces include individuals who range in statures and body types.

Youth of different ages vary widely in height, weight, and strength, regardless of gender. For example, at twelve years of age, size and strength may range from adult to childlike characteristics. Similarly, some females may be bigger and stronger than males within a similar age group. Therefore, it is important to recognize these differences when developing effective intervention strategies for children/adolescents. There is a need to determine what ergonomic interventions have been implemented and to document the interventions and make them accessible to the general public. A NIOSH document titled *Simple Solutions: Ergonomics for Farm Workers* (NIOSH, 2001) provides an example of some interventions for farm workers. In addition, there are interventions pertaining to children/adolescents in other topic areas such as nutrition, sex education, and smoking. Perhaps these methodologies could be adapted to the agricultural environment.

Even though intervention training programs are desirable, it has been shown that these are generally ineffective in reducing the risk of WMSDs. The panel agreed that interventions could be viewed in two basic ways: (1) general/national interventions which include such things as organizational and administrative interventions (e.g., school breaks, work-rest patterns, training and education programs); and (2) engineering controls.

In other industries, engineering controls have been shown to be the most effective method of reducing the risk of WMSDs, especially when emphasizing a more mechanized approach. For example, in the nursing home industry and in hospitals, where numerous non-engineering techniques (e.g., teaching, education) were the sole intervention strategy, only limited success has been demonstrated. When engineering controls, such as patient transferring devices and ergonomic beds were properly implemented, however, there were marked decreases in the incidence/risk of injuries, lost work days, and workers' compensation claims.

Due to the risk of WMSDs, there is a need in agriculture to evaluate and re-

design many jobs and tasks. Work tasks for which there are no interventions need to be identified and new tools and methods should be developed. Private industry should be involved in development of engineering controls. The panel wondered why manufacturing industries are not putting more effort or funding into research and development to design solutions for preventing musculoskeletal disorders resulting from poorly designed equipment. The nursing and health care industry did not accept engineering controls until researchers conducted studies which showed that the mechanical lifting assistive devices could prevent injuries and reduce lost work time due to injury. Since then, the number of devices created has increased dramatically. The panel also indicated that cultural barriers may impede adoption of engineering controls in some cases. Moreover, when addressing youth, manufacturers may be concerned about liability issues in terms of how to design equipment for younger individuals. For example, should respirators be made for young children? A point was made that it is critical to distinguish between engineering methods, where hazards are removed, and methods designed to change the work process or work method. It seems that the question of hazard abatement in the intervention community is undervalued. Ultimately, removal of the hazard is the main goal, but the remaining effort does involve education, administration, and public awareness. One solution may be to identify individuals who have an ergonomics background in agriculture and involve them in public awareness efforts.

Development of Request for Proposals (RFPs) or Request for Applications (RFAs) must follow standard government procedures, but attempts should be made on the part of funding agencies to target proposals at individuals with specific background and work experience in developing agriculture related interventions, while taking care not to jeopardize their ability to apply for the funding. It was also noted that there needs to be applied intervention research, and

that the evaluation criteria of RFPs/RFAs should be flexible.

An additional concern is that in theory eliminating the hazard sounds promising, however, in reality, a known effective intervention simply may not be utilized. An intervention might be in place, but someone might disable it. For example, a significant problem in agriculture is tractor overturns. Evidence has shown that Rollover Protective Structures (ROPS) combined with seatbelt use is 99% effective in preventing death. Although this combined intervention (i.e., seatbelt, ROPS engineering control) is widely available and easily accessible, there is little evidence that seatbelts are widely used by tractor operators.

A suggestion was made that NIOSH take a holistic view of interventions. While an engineering intervention may be the optimal approach, it is not the only approach. For example, one program used adult migrant workers to reduce the labor needs during peak times on the family farm. This reduced the time that the farm children/adolescents were in the fields. Unfortunately, the number of participants in this intervention was small, and it was difficult to know whether decreased exposure led to decreased risk of WMSDs. Still, this represents an administrative control.

When trying to decide whether an administrative or engineering approach would be most effective in reducing risk of WMSDs for a particular situation, each circumstance should be evaluated individually. Engineering controls are generally more effective in the long run, and are usually preferred, but may be expensive. Administrative controls, however, may be just as effective in some situations, but may or may not be less expensive or easier to implement than an engineering control. To deal with this issue, perhaps a recommendation could be made that an administrative measure may be suitable as an interim measure until an engineering control can be developed. Although the ultimate goal of the health community may be reduction in risk of WMSDs, researchers may have to frame the idea in economic terms to achieve buy-in, such as increased productivity, increased profit, and creation of jobs for adult migrants.

For many interventions, the distinction between administrative, educational, and engineering controls is vague. It is not likely that an engineering control will be put into place unless someone accepts that it will be effective and is willing to pay for it. This requires public awareness of intervention effectiveness. Similarly, workers need to be convinced that a new work process or tool is worth using. Hence, the typical hierarchical intervention is often misunderstood. Even substitution requires the realization that hazard elimination is important.

In summary, the panel noted several potential intervention solutions. First, new tools and equipment need to be developed. This could involve encouraging private industry to take some responsibility for eliminating WMSD risk factors. This could be accomplished by encouraging partnerships with government and academia to help develop improved engineering controls. Second, new work processes and practices need to be developed and evaluated. Third, acceptance/adoption of interventions (e.g., best practices and/or new equipment) should be increased through information dissemination and public awareness. Fourth, solving liability concerns and overcoming cultural/ethical barriers need to be addressed.

Several issues were raised regarding the design and implementation of intervention effectiveness studies. Although randomized control trials are considered the "gold standard," other types of evaluations should be considered. These would include qualitative research evaluation approaches, less formal methods such as methods of perceived exertion, and/or blended designs with qualitative and quantitative methods which include participatory action/social research and measuring variables multi-dimensionally. One problem with randomized control trials is the assumption that the only difference is the intervention and that all else is equal, such as exposure. Such studies are also expensive to conduct, time consuming, and may not be applicable to all situations. NIOSH published a *Guide to Evaluating the Effectiveness of*

Strategies for Preventing Work Injuries that discusses important intervention study issues (Robson et al., 2001).

Consideration should be given to incentive/motivational programs, such as the Iowa Certified State Farm Project, where owner/operators are given $200 if they adopt certain practices that eliminate poor work practices. Children/adolescents would enjoy being involved in the creation of solutions, and those who are actually engaged in the tasks should be involved in designing interventions. NIOSH and universities could partner with high schools, vocational schools, agricultural engineering schools, land grant colleges, and so on to have contests for the development of interventions. Simply by running contests and receiving information as a result, researchers would gain insight into what people perceive as solvable problems.

An optimal intervention study would have a pre-test and a post-test, and investigators would assess changes such as levels of symptomatology. A cautionary note was expressed, stating that while this kind of information is valuable, it may reflect temporary effects rather than long-term ones. It is also difficult to study a reduction in injuries. While the overall incidence of injuries may be high, specific problems (e.g., carpal tunnel) are relatively rare.

Etiologic Issues

The panel first clarified that they were defining the term "etiology" as cause, and they acknowledged that the debate and uncertainty about the etiology of WMSDs, even in the adult population, persists. Therefore, it did not seem profitable to attempt to solve all etiological uncertainties associated with adult disorders. The panel also acknowledged that firm etiological connections are not absolutely required for making logical, sound intervention efforts. For example, smoking cessation programs started long before the details of the carcinogenic effects were known. There was general agreement that

even with limited information, interventions should proceed. Although the panel agreed there should be flexibility for researchers in proposing studies and study designs, they did make suggestions about study types and designs. The panel also considered the pros and cons of various methods of study, and what type of data each method could produce.

An underlying hypothetical question was posed regarding etiologic issues. Is there any kind of permanent consequence of repetitive physical exertion among children/adolescents not seen in adults, or are health consequences only a matter of degree or duration of exposure? For example, lead exposure in children can result in a permanent IQ deficit, which is influential throughout life. Is there a similar analogy for WMSDs? It was noted that adult farmers have much higher rates of WMSDs than the general population. This raises the question: Does work by children/adolescents on farms who may be going through growth spurts and being exposed to physically demanding jobs, create any permanent damage that may lead to higher incidence rates as adults? For this reason, temporal exposure patterns may be important in determining whether there are long-term risks.

The group discussed options for studying the potential long term effects of exposure to physically demanding jobs for children/adolescents. One suggestion for a study was to identify appropriate populations of adults who were exposed as children/adolescents and compare their current MSD health status, while controlling for exposures beyond childhood. This could be accomplished by identifying three specific exposure groups: (1) those who did farm work only their entire life; (2) those who worked on the farm as children/adolescents and then performed factory work only as adults; and, (3) those who performed a combination of farm work and factory work as adults. In this setting, there would likely be individuals who stayed on the farm, some who moved to the city

and worked in a factory, and also a large number (if this is a small enough community) who stayed on the farm and worked in a factory. Another option would be to identify a cohort of adults who did farm work as children/adolescents and then categorize them according to their adult exposure, as defined by years of exposure and level of physically demanding work in all types of work settings. In this model, continuous farm type exposures could be compared to other types of long term exposures with variable amounts of physical demand. A note of caution was there could have been many changes in technology which would argue against such a study.

One problem with etiological studies is how to identify and measure different outcomes that may be related to exposure. There are physical outcomes as well as possible psychosocial and developmental outcomes as a result of high demand physical work. This is especially true among children/adolescents, particularly in the group who are working extremely long hours. If even 5% to 10% of children/adolescents are working long hours, it is possible that there are psychosocial and developmental issues that those children/adolescents will face (e.g., less education, less economic opportunity, poor health, and the potential problem of other outcomes such as alcohol and substance abuse). It may be virtually impossible, apart from acute traumatic events, to relate in any but the loosest biological way, the true association between exposure to physical stress and long term health outcomes.

Therefore, it would make sense to examine other outcomes that are primarily theoretical but, which have been demonstrated in the past. For example, it is known that alcohol/substance abuse is a problem in many communities. What is not known is the relationship between work among children/adolescents and alcohol or substance use in rural communities, or what the relationship is between heavy physical work or long work hours and eventual educational outcomes among children/adolescents in rural communities. Even given mod-

est budgets, these relationships can be evaluated, and while not specific to the issues of heavy work load, it would argue strongly that there are other reasons to decrease workload for these children/adolescents and to work with families in other than traditional ways to attempt to decrease the burden of work because of its purely physical outcomes.

It was brought to the panel's attention that little research has been conducted examining the physiological link between WMSDs and children/adolescents working in any jobs. The void is not just in agriculture, but in nearly every area. To date, some very rudimentary guidelines have been created as the result of convening a consensus group which identified a list of types of agriculture jobs in which children/adolescents are involved. There may be some surveillance data on youth, who work, but these data focus on safety issues. It does not appear that studies have been conducted examining the effects that sports and other outside activities have on the development of musculoskeletal problems in children/adolescents who work. Imbedded in all child/adolescent work are the psychosocial/developmental issues. It was suggested that use of the adult model would be acceptable, because otherwise, investigators would be "starting from scratch." However, two problems exist: (1) Once it has been shown that WMSDs are a problem for children/adolescents working today, it may be difficult to convince anyone to conduct this type of study; and (2) it is not clear whether exposure to heavy work as a child is a long-term health problem, and this will be harder to deal with because of the longitudinal nature of the situation and the difficulty in conducting prospective studies. It is not clear whether farm families would consider subtle long term issues, such as prevention of chronic WMSDs, considering the reality that they often fail to implement economically feasible interventions for acute safety problems. For example, some farm families resist spending $300 for a ROPS device to be installed on a tractor, which would be worth the small investment.

Studies are needed to determine the relationship between long work hours and development of WMSDs in children/adolescents who work in agriculture. If researchers demonstrated that long hours of work have adverse effects on the health of children/adolescents, parents might take action, but generally the reality is that these families are desperate for labor and wouldn't make many changes. Documentation of hours of work will be problematic due to irregular hours of work, daily and seasonal fluctuations in work demands, and the integration of school work, non-farm work, and sports will make it difficult to determine the extent to which long hours of agricultural work contribute to development of WMSDs.

Another etiological area of interest is the interaction between physiological development and task load. In cross-sectional studies on children using book bags, it has been shown that carrying heavy book bags results in increases in bone density and reports of neck, shoulder, and back pain. These same concerns are applicable for children performing farm work. While growing children need physical exertion to develop their bodies, the type and magnitude of exposure to physical loading involved in agricultural work is very important. The type of loading needs to be determined for appropriate growth of the muscles and the skeletal system. An indication of the potential problem may be reflected in studies of adults that have shown that there is increased risk of osteoarthritis or degenerative joint diseases among adults due to high mineral content, bone density, and bone stiffness. Theoretically, heavy physical demands on children /adolescents may cause the bones to grow the wrong way or become too stiff, resulting in higher transmissibility of forces to the joint surfaces. These increases in bone density may be precursors or early indicators of chronic musculoskeletal disorders. Therefore, additional research studies examining the effect of physical exertion and type of loading on growth and development are needed.

Another area of concern was the interaction between exposures to pesti-

cides combined with heavy physical work. Exposures to pesticides may affect muscle strength and/or other neurological functions. A pesticide applicator study conducted 12 years ago demonstrated a significant decrement in neuromuscular performance among applicators compared to the non-exposed group. Farmers were clinically tested during the later months when not working, and pesticides were found to have chronic effects. Thus, it appears that the chemical environment might be contributing to the injury/insult. Similarly, there are studies conducted by George Washington University epidemiologists that have shown that people who have chemical exposures in construction are at higher risk of experiencing injuries compared to those who are not exposed to chemical hazards, but who are engaged in similar physically demanding jobs (Welch et al., 2000). What is not clear is whether the resulting neurological dysfunction causes these workers to have more injuries, or if there are actual physiological changes due to exposure that are linked to an increased frequency of WMSDs. The magnitude of the increased risk due to the interaction between childhood pesticide exposure and physical demands is not known. It was noted that, at least in some states, most children less than 18 years of age are not applying pesticides on family farms. Exposures to pesticides and perhaps multiple other chemicals may come from sources other than direct spraying. Exposure could be airborne from the family farm (e.g., commercial applications) or other nearby locations (e.g., adjacent farms) where individuals are applying agrochemicals, through groundwater contamination, or food consumption. The question would still apply as to what extent there is a link between children exposed to pesticides and interaction with physical demands to cause increased risk of WMSDs if the children are engaging in physical labor and are exposed to pesticides, regardless of routes of exposure.

Another suggestion for studying the chronic aspects of WMSDs was to consider current farmers in their late

20s to 40s, and to obtain a retrospective history to find out what they did as children on the farm to learn whether their current health status relates to their exposure levels as children. For this, investigators would need an appropriate comparison group, one not working until around age 18. There could also be a group who started doing physically demanding work as children but who are not currently doing physically demanding work. Scandinavian studies published 15 to 20 years ago showed that persons who worked in physically demanding jobs such as labor and construction work had much worse musculoskeletal and neuromuscular health status than persons who have not done physically demanding jobs during their lives (Arndt et al.,1996). This approach is currently being used in a study in Cincinnati with retired construction workers. In this study, the current health status of construction workers is being compared to the health status of a comparison group who worked in non-physically demanding jobs all of their lives. Results are showing significant differences in the health status at retirement age of these two groups (Lemasters et al., 2003). The study was prompted because construction workers have a life expectancy of five years less than the rest of the workforce. Convening focus groups might be beneficial for gaining further insight in this area.

In terms of dose-response relationships, the argument was raised that the most severe cases of likely WMSDs would occur among those who have the greatest exposure, and that exposure is likely to maximally affect those who engage in a certain type of work for the longest period of time. A suggestion was made that the migrant child/adolescent population probably would afford investigators the opportunity to identify a specific job or series of jobs without many confounding factors. Identifying the most severe cases would allow investigators to put boundaries on the maximum effect of exposure. If the maximum effect is no different than for an adult, then conclusions about the general population could possibly be made. Re-

gardless, the limits would be approximately known and information would be available to develop a strategy for dealing with exposure issues. Another reason why migrant child/adolescent workers might make a suitable study population is that they may not spend as much time playing sports as non-migrants. Also, there may be good records regarding the number of hours worked for a migrant child/adolescent population, reducing the problems of relying on recall. The thinking is that the child/adolescent on the farm is likely to be engaged in more variable work than the migrant child/adolescent worker who may be doing the exact same work task over and over.

Broadening the spectrum of possible contributing variables to WMSDs with dose-response research may have more credibility. In other words: How does dose affect one's overall response throughout the continuum of response during childhood, young adulthood, and later in life? Also, what role does genetics play? While the exercise physiology literature may provide some guidance, it is still not clear what the influence of genetics is among different individuals. There was general agreement, however, that ultimately, genetic variability would not matter that much with respect to risk of WMSDs. There was general agreement that while genetics should be acknowledged as a possible factor, some believed that including genetic considerations in studies may be too premature given the state of the science and the substantial increase in cost involved. Family, social, and environmental history would seem significantly more important than specific genetic factors.

It was recognized that, while the mi-

grant child/adolescent worker population could serve as a model, other potentially exposed groups should not be excluded, but identified. Certainly, from a study design standpoint, examining migrant child/adolescent workers may be a better model, but investigators cannot be too narrow in their selection of exposure groups. Also it was pointed out that even migrant workers engage in a range of tasks. For example, work on a livestock farm would involve mixed tasks, such as lifting, stooping, and bending. In an effort to establish the dose-response relationship, investigators probably need to narrow the area of focus. The question is, are they trying to find a dose-response relationship that encompasses all the relevant exposure variables or a subcategory of dose-response relationships based on populations that focuses on more narrowly defined relationships such as exposure types or type of work enterprise?

The panel discussed potential problems in designing a dose-response study for children/adolescents. Since youth less than 18 years of age may be involved heavily in sports, and may work both farm and non-farm jobs, it was suggested that investigators capture as best they can what children/adolescents are really doing in order to conduct a proper exposure assessment. Based on the deliberations of the group, it appeared that what they were most concerned about was the difficulty in estimating exposure when it was highly variable and when individuals did a variety of activities. In addition, chemical exposure would need to be evaluated.

Several of the questions which need to be answered include: (1) Does heavy work in youth lead to more problems in adulthood than one would have otherwise?; (2) How heavy is too heavy?; and, (3) How can the exposures of today be generalized to the problem of later development?

It was noted that investigators will likely face many different mixed exposures, so if they start ruling out potential participants because of mixed exposures, they might find the study

compromised. One goal might be to track exposure history back to activities before participants were 18 years of age, especially looking at heavy physical labor on the farm that started at approximately age 10. Ten years of age would most likely represent a starting point before any of the other co-factors were present.

One suggestion offered was to recommend that investigators initially focus on migrant child/adolescent workers. This group might provide participants that would be most likely to consistently work the same job. Within that group, it might be possible to consider those who started working jobs at age 12 or 14 versus those who started at age 19 or 20. This would remove a lot of the complicated issues from the study (e.g., intervening variables or co-factors). This method/approach would not address some of the problems with farm family youth, but it may assess the impact of work at a young age. Nutrition may also play a factor. For example, the Hispanic child/adolescent population may have a very different nutritional background than the age matched population of Midwest farm children/adolescents.

There may be value in conducting some of the studies in developing countries because this would likely produce a better set of data (e.g., less complicated work and lifestyle histories) that would be easier to analyze, although nutritional issues must also be taken into consideration. Because of differences in nutritional issues, educational factors, and underlying public health problems, our ability to understand the etiology of WMSDs may be difficult. Moral and ethical concerns, however, were expressed with regard to conducting investigations in developing countries. Ethical questions arise as to whether it is appropriate to go to a developing country, determine the scope of a problem both for their country and the U.S., but then only implement interventions in the U.S. If there is a commitment to provide resources for interventions in both countries, then the ethical issues surrounding studies in developing countries might be less-

ened. Others argued that information would be learned that could then be passed on to the researchers and manufacturers who might, in turn, create new ergonomic tools that would be purchased worldwide.

Ultimately, panel members agreed that tools and guidelines are needed to limit exposure to physical stressors. Although information about the general physical characteristics and mental capabilities of children/adolescents at different age group are known, more detailed information about strength (e.g., static and dynamic), endurance, and posture capabilities at each age level are needed. In order to design appropriate jobs for children/adolescents, studies should be conducted to assess these factors for children/adolescents who work in agriculture. For example, what is the appropriate weight limit for lifting for various ages and genders, and what factors would affect those limits? If investigators have some idea about physical capacity, they can relate this to long-term impacts. Variability of capabilities among children/adolescents, where even children/adolescents of the same age exhibit large differences in strength, must be considered. Panel members, however, thought that methodological issues would require significant attention in these studies.

Researchers must determine the nature of exposures and symptomatology for children/adolescents working in agriculture. If an increased risk of WMSDs can be demonstrated, visibility for the issue will be increased and the importance of controlling the hazard will be recognized so that it will be taken seriously and attract funding. One idea presented was to conduct a cross-sectional study with a heavily exposed group and control group to show that, in agriculture, there is a significant risk of WMSDs for children/adolescents. Moreover, qualitative or exploratory research (interviewing parents, children, providers, teachers, young adult farmers, social services) also could be beneficial given that there is still limited evidence about the extent of the risk of WMSDs for children/adolescents.

The major demographic and individual factors influencing the development of WMSDs could be determined with a properly designed case-control study. Case control studies are generally more affordable than other types of designs, but case identification is sometimes difficult. The case-control study might be able to answer questions regarding whether gender, age, growth spurt, other individual risk factors, and anthropometry play significant roles in the development of WMSDs. If the mechanism for finding cases was efficient enough, the lag time between a child having contact with a reporting system and investigators finding out about it could be minimized.

Alternatively, a prospective cohort study would allow better documentation of exposure as well as other parameters such as symptoms of pain, fatigue, discomfort. Also, there is less concern about recall bias with this design. One way to design a study would be to compare differences in the health outcomes for a cohort of children who work in agriculture to a group of children who do not work in agriculture, while controlling for outside activities and school. The children who work in the agricultural setting may be stronger, and have more endurance than children who are not working, but they may suffer more musculoskeletal injuries and miss more school.

Summary Findings

Upon completion of deliberations of the questions posed, the panel was asked to evaluate the issues listed from the discussion and to make specific suggestions regarding what they perceived to be the top five research issues in each category (i.e., assessment of high-risk jobs, surveillance, intervention, and etiology). These suggestions represent the general agreement of the panel members, but they are not intended to be a consensus from the panel, nor do the suggestions appear in any rank order.

Suggestions for Assessing High-Risk Jobs

1. **Develop an "Enterprise Classification" system and evaluate risk of WMSDs based on this classification (e.g., determine risk by region, agriculture sector, or size of enterprise).**
2. **Determine the number of exposed youth and what jobs they are doing in each commodity area.**
3. **Evaluate risk in unmechanized production (e.g., tool usage in manual labor).**
4. **Identify the hazards or physical work factors in each job or task and determine the number of hours worked per year.**
5. **Evaluate the effectiveness of different methods of risk assessment, including self-assessment, professional judgment, and objective quantitative methods. Use "health outcome" or "level of exposure" as a measure of risk.**

Suggestions for Surveillance Research

1. Develop a national registry of musculoskeletal hazards and health outcomes .

2. Supplement existing surveillance systems (e.g., NHIS, NHANES, BRFSS, California Department of Health, and prospective community-based surveys such as Keokuk and Iowa Safe Farm).

3. Conduct *ad hoc* population-based health and hazard surveys (e.g. clinic- or school-based methods or face-to-face interviews).

4. Develop partnerships with individuals or agencies that interact regularly with children and adolescents working in agricultural settings.

5. Conduct cross-sectional and longitudinal studies to develop and validate a list of high risk jobs and significant health outcomes.

Suggestions for Intervention Research

1. Develop private industry, academic-industry and state agency partnerships. For example, a vocational agriculture awards program for interventions at the high school or college level.

2. Develop improved methods for disseminating information.

3. Conduct studies that address liability, cultural, ethical, and economic barriers to implementing interventions.

4. Encourage more high quality intervention evaluations using randomized trials, quasi-experimental studies, and blended evaluations.

5. Investigate use of existing or modified models for increasing adoption of interventions based on similar successful models, such as the NIOSH hazard control hierarchy model for injury prevention or the tobacco risk awareness model.

Suggestions for Etiological Research

1. Conduct studies to assess physical, cognitive, and developmental capabilities of children/adolescents.

2. Conduct studies to determine the magnitude of exposures and symptoms for children/adolescents in agriculture, including examination of multiple exposures (e.g., sports, second job).

3. Develop and evaluate improved methods for measuring exposure, health outcomes, and other etiological factors.

4. Conduct population, clinical, and laboratory studies to evaluate the short-term impact of risk factors on WMSDs, such as effects of different types of exposures on MSD risk and early indicators, such as biomarkers, bone density, stiffness, and pain.

5. Conduct population, clinical, and laboratory studies to evaluate the long-term impact of repeated exposure. Examples include studies to compare health status of retired farmers compared with non-farm workers and evaluations of the permanent effects of physical loading (studies should include groups with maximal exposures).

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List of Attendees

Steve Bartels M.S.
Butler County Extension
Ohio State University Extension

Amit Bhattacharya Ph.D.
Department of
Environmental Health
University of Cincinnati
Medical College
3223 Eden Ave.
ML #056
Cincinnati, OH
45267-0056

Stephen Brightwell
NIOSH (MS C24)
4676 Columbia Parkway
Cincinnati, Ohio 45226

Larry Chapman Ph.D..
University of Wisconsin Madison
460 Henry Mall
Madison WI 53706

Janet Ehlers R.N., M.S.N.
NIOSH (MS R21)
4676 Columbia Parkway
Cincinnati, Ohio 45226

Cherie Estill M.S.
NIOSH (MS C24)
4676 Columbia Parkway
Cincinnati, Ohio 45226

Fadi Fathallah Ph.D.
Biological and Agricultural Engineering
University of California
One Shields Ave.
Davis, CA 95616

Arun Garg Ph.D.
Department of Industrial and Manufacturing
Engineering
P.O. Box 784
University of Wisconsin - Milwaukee
Milwaukee, Wisconsin 53201

Pamela Kidd Ph.D.*
Associate Dean Graduate Programs and
Research
Main Campus
PO Box 872602
ASU College of Nursing
Tempe, AZ 85287-2602

Carol Lehtola Ph.D.
Dept. of Agricultural & Biological
Engineering
P.O. Box 110570
The University of Florida
Gainsville, FL 32611-0570

Barb Marlenga Ph.D.
National Children's Center
National Farm Medicine Center
1000 N Oak Ave. - ML1
Marshfiled, WI 54449

***Deceased**

John Miles Ph.D.
Bio and Ag Engineering Department
University of California
One Shields Ave.
Davis, CA 95616

Dennis Murphy Ph.D.
Agricultural & Biological Engineering
Pennsylvania State
University
221 Ag Engineering
Building
University Park, PA 16802-1909

Stephen Olenchock Ph.D.
NIOSH (MS P04/1119)
1095 Willowdale Rd.
Morgantown, WV 26505

David Parker M.D., Ph.D.
2808 River Parkway W
Minneapolis, MN 55406

Ted Scharf Ph.D.
NIOSH (MS C24)
4676 Columbia Parkway
Cincinnati, Ohio 45226

Tim Struttman M.S.P.H.
Kentucky Injury Prevention & Research
Center
University of Kentucky
333 Waller Avenue,
Suite 202
Lexington, KY 40504-2915

Thomas Waters Ph.D.
NIOSH (MS C24)
4676 Columbia Parkway
Cincinnati, Ohio 45226

J. R. Wilkins III BCE, DrPH
Division of Epidemiology and Biometrics
School of Public Health
Ohio State University
Columbus, OH 43210

Huiyun Xiang M.D., Ph.D.
Colorado Dept. of Public Health & Envir.
4300 Cherry Creek Drive S. Denver, CO
80246-1530

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226-1998

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