Surgeon General's Conference on Agricultural Safety and Health
FarmSafe 2000 • A National Coalition for Local Action
Convened by the National Institute for Occupational Safety and Health
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FARM MACHINERY AND VEHICLES

By Thomas L. Bean, Ph.D.
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Preparation for this presentation included the review of literature, accident reports, unintentional injury data, and technical and professional papers from the United States and foreign countries. One of the earliest was a 1931 study by J.R. Jewell from the Cooperative Extension Service, University of Nebraska. After such an extensive review, it is appropriate to provide a broad, general brush to this topic and indicate the most significant items that stood out as general findings, which seemed to run as a thread or recurring theme in much of the literature.

AGRICULTURE, A HAZARDOUS OCCUPATION

The most obvious finding was that agriculture, based upon statistical studies, was usually classified as a hazardous industry or occupation. Most early studies concentrated on on-farm injuries as occupational in nature. In either case, the majority of studies indicated that farm equipment was the single factor most associated with on-farm injury.

Farm equipment accounted for 40 to 60 percent of deaths and injuries in the majority of studies, followed very closely by livestock injuries and falls. Numerous types of farm machinery have been implicated in all studies. Since the majority of farm machinery is associated with tractors, it stands to reason that injuries "involving" tractors were the most common type of machinery-related trauma.

Tractor over-turns, it appeared, were involved in the majority of agricultural fatalities. Many studies indicated that youth and the elderly were most often associated as an at-risk population.
The studies varied, though, when you compared those using statistics from government agencies that were not gathering the appropriate and associated data with youth.

In either case, the majority of studies indicated that farm equipment was the single factor most associated with on-farm injury.

Injury data for youth under a certain age was often excluded from the data base. Many studies conducted by those of us in the field have included unintentional injuries, which have occurred in the lower-age group, and recognize the associated problems.

GENERAL DUTY

The opportunity presents itself to include some homespun theory. This happens to be a theory of mine: on family farms, older tractors and equipment are often reserved for general duty while newer

pieces of machinery are delegated to more production types of tasks. The general duty may be more hazardous than the normal production tasks on farms.

As a result, general duty is often done by the youth or the elderly. The typical farmer, the principal operator, is using the newer machinery to plow and till the field, etc., while the older machinery may be relegated to cutting the fence rows or ditch banks and stationary operations that may be more hazardous than doing field-related operations. As a result, when you combine the inexperience of youth and the diminished capacity that comes with aging (because the elderly or youth usually do this general duty) with the inherent danger of the equipment, you have an increased potential for trauma.

HIGHWAY HAZARDS

Few studies have centered on farm machinery and the hazards associated with highway travel. This is an area that needs additional study.

A recent study by *Farm Journal* surveyed 100 of their readers. Those readers indicated that traveling on roads to reach the field was one of their primary safety concerns. Of concern to these readers were faded slow-moving-vehicle (SMV) emblems, implements without brakes or lights, no turn signals, no clear differentiation between the turn signal and the flashers, and no stops or pins to hold the equipment in transport. Some equipment is held in transport by the hydraulics.

There is also a problem of farm vehicles being exempted from state motor vehicle laws. These exemptions are based on agriculture being a protected class, similar to the farm exemption by OSHA. The protection agriculture is given as a protected class varies from state to state.

A review of state laws will reveal that a farm tractor is usually well-defined, which means that many state legislatures can recognize a farm tractor. However, when you explore legislative definition of implements of husbandry, farm machinery, farm wagons, farm trailers, or special vehicles (another term in many state laws for such farm equipment), you discover a gray area. The typical legislature fails to define them.

Exemptions are set by definition or the lack of definition. This is the problem. It is a learning activity that needs to be conducted with state legislatures.

Farm vehicles—varying, again, from state to state—may be exempt from registration. They may be exempt from any kind of inspection, adequate lighting requirements, braking requirements, or other requirements, which are normally associated with other types of vehicles.

As an example, if you study the West Virginia laws, you will find that farm vehicles may be exempt from braking requirements. If you do not have to have brakes, you are exempt. As for a driver's license, most states exempt agricultural vehicles and, therefore, the people that run them, from any kind of licensing requirement.

Age or physical condition does not make any difference. They are exempt by definition. It is a problem.

An eight-year-old can operate a farm vehicle on roadways. Yet all other drivers may need a driver's license to operate motorcycles, cars, buses, trucks, etc. This is not so for farm machinery. This is a sample of

the many other exemptions caused because agriculture is a protected class.

STUDIES IN OHIO

Some of the studies that we are doing in Ohio, I will briefly present to you. We have a project now with a special agricultural population, the Amish.

Buggy Safety

If you were to view Ohio highway safety statistics, you would find there are three classes of agricultural highway accidents. One is tractors, the second one is farm machinery, and the third one is buggy accidents. Are buggy accidents part of the agricultural problem?

The answer is probably, because the Amish really only use buggies for two things:

1. To do some activity concerning the farm.

2. To go to church.

So buggies can be a potential agricultural problem. We are embarking now on an effort to work with Amish youth in their schools on safe buggy operation.

Highway Safety

We are conducting a second project in cooperation with our Highway Safety Office. In the fall, we will be conducting a survey of 1,200 farms in an effort to get the farmers' perceptions of the hazards of operating agricultural equipment on the state and county highways in Ohio:

1. What type of equipment is actually being operated on the roadways?

2. What are the conditions under which farm machinery is moved on the roadways?

3. What are the major problems with operating farm equipment on roadways?

4. What is the road worthiness of farm equipment?

RECOMMENDATIONS

Although there are many that could be made, the following are some recommendations for research and action.

1. We need to continue efforts in research on human sensors and automatic shut-offs. If a person is too close to the tractor in a given situation, it should not start or continue to operate.

2. Research on roll-over protection on older tractors should continue.

3. There should be aggressive inclusion of safety in all of ASAE and other standards.

4. There should be research conducted on the lighting and marking of agricultural equipment.

5. There should be some consideration for a uniform motor vehicle code on farm tractors and machinery used on the highways, including set definitions of types of agricultural equipment. This would provide a model for states to consider in future legislation.

6. There should be continued studies on agricultural safety educational techniques that work.□

REFERENCES

1. Jewell, JR; Farm and Home Accidents: Their Cause and Prevention. Extension Circular 5578, University of Nebraska (1931).

2. Ottey, Audra and Charlene Finch; "Farm Journal Survey Shows Road Travel Tops List of Safety Concerns." *Farm Journal*, Volume 115, Number 3, February 1991.

QUESTIONS

John Hahn: I am with the Iowa Division of Labor. Regarding the ROPS, the rollover protection on the tractors, I have heard no mention about the need to use a seat belt or a safety harness to keep from being thrown out of the tractor on to the ground where you can be crushed by the crush-proof cage as it rolls over.

Dr. Thomas Bean: Definitely that is a problem. We—I say we-a lot of us know that that is a problem. I can go to any farming group, and I ask how many have rollover protective structures—either cabs or poles—and get a good many hands. Then I ask the next question, "How many use their seat belt?" You will probably find zero or very few. We realize that it needs to be addressed as a behavioral problem. Farmers tell me the reason is because they get off and on their tractor so many times. Something has to be designed or implemented or there has to be education about what is acceptable to that group as far as belting them in on the tractor. Often I try to use the example of highway safety and ask them, "Do you use it when you ride on the highway, at least?" Still the answer is very, very low.

John Hahn: With seat belts on things like tractors—I once looked into seat belts on forklifts, and there is a big controversy on forklifts, and there is something that they call the fly swatter effect. That is, when you fall off an elevation on a forklift, is it better to be fastened in there so that when you hit, your head goes bump, bump, bump against the pavement, or is it better to be unrestrained? There probably is some of that in agriculture also.

(inaudible): I am back. One thing on your comment on the forklift. Generally, other construction equipment works with a seat belt. What some companies have done to keep the guy's head from being pounded into the ground is just to take metal screening or expanded metal and put it on the side and that way he can just cut his head up once against the screening when he goes.

John Hahn: I was talking about forklifts. I just might add, I know that there are a lot of problems on the issue of seat belts, when you put a screen or that type of thing on. I know it is more of an issue in logging than it is, maybe, in farming, but the idea is that once you put that screen in, you have now taken that person, and if he has the seat belt on, he can become a human pincushion. The point I was trying to make is, this whole issue of seat belts is a very tough one because, depending on what industry you are working in, there were a lot of complaints when NIOSH talked to OSHA and recommended seat belts on skidders in logging. The main complaint we had was you had screening devices on those skidders to provide something like a cage for that person while he is in the skidder. When it rolls or rolls over or while he is moving through the woods, if sticks, and that kind of thing comes in through that mesh, he cannot get out of the way if he has his seat belt on. I have not heard that complaint yet from farmers, but at the same time, these are the types of issues that you have to learn to resolve when you start talking about the use of seat belts on this type of equipment. There are other factors that we have to be aware of and we cannot make just a blanket statement that seat belts are the best until we start getting some good information and look at some of the other types of alternatives, such as possibly a seat bar. We are not sure what is going to work.

(inaudible): I just have a comment on the seat bar versus seat belts. In Canada, log skidders are being equipped with seat bars, and it looks like they are getting very popular.

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MUSCULOSKELETAL HAZARDS

By David Cochran, Ph.D.
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Good afternoon. I feel a little out of water in that my specialty is not in agriculture. I have been asked to talk about ergonomics, musculoskeletal disorders, and agriculture.

As I started thinking about the agricultural environment, I realized that I see it as a hostile environment. It is about as hostile an environment as we have in this country. We have chemical and dust hazards, machines that can take your bodily parts rather easily, slips and falls, amputations, death, noise, and temperature hazards, including cold stress and heat stress. We also have whole body and segmental or limb vibration, explosions, and infectious diseases. Lastly, on my list, we have musculoskeletal hazards.

Quite honestly, I think most of you and most people in agriculture do not consider musculoskeletal disorders or musculoskeletal hazards very much. If you do, you think of back injuries. Back injuries probably are far and away the biggest problem that my discipline, which is ergonomics, deals with.

There are, however, cumulative trauma disorders of other sorts. I consider back injuries cumulative trauma. In many cases it is a one-instance injury, but in most cases we strongly believe that they are cumulative. The more times you lift excessive weight, the more times you stress your back or strain it, the more likely it is that you will have a back injury. It is a cumulative problem.

In addition, we have problems of the upper extremities. I am going to go into that in a minute. I thought, that problem is probably not present in agriculture.

I was talking to a friend of mine, Barbara Silverstein, who was with the University of Michigan and is now in the state of Washington. She was telling me that the top occupational category suffering from tendinitis in the state of Washington is farmworkers. They do not have the foggiest idea why or where it is occurring.

Ergonomics and cumulative trauma do exist in agriculture, and probably a lot more than we realize.

CUMULATIVE TRAUMA DISORDERS

Now, being a professor I have to educate a bit, just in case you do not know some of the things that I think are important. I am going to talk about some of the cumulative trauma disorders. These can be of the upper extremity or the lower extremity—not necessarily concentrating on the back.

Tendon-related Disorders

First, tendon-related disorders usually occur by overuse of, or stretching of, or excessive forces exerted by these tendons. The most common is tendinitis, inflammation of the tendon tissues. Another very

common illness is tenosynovitis, separate or concomitant inflammation of the tendon and its sheath.

I normally think of it as the sheath. I do not know how good your anatomy is, but we have tendons. Tendons really are cables in the body. Around those, in strategic locations, we have soft tissue that protects the tendons, called sheaths. They are a lubricated tissue. As the tendon slides around a corner or moves past bones, it is protected by the tendon sheath. When the sheath becomes inflamed, it is normally called synovitis. Sometimes when the tendon is involved it is tenosynovitis. This is common in normal manufacturing operations. It probably is common in farming or in agriculture, but we do not have much data.

Carpal Tunnel Syndrome

Second, carpal tunnel syndrome gets all the press. It is a problem in the wrist. One of the nice things about this one is that all the reporters are suffering from this. Since they are suffering from it, they write about it. There is nothing like having an interest in your own preservation.

Carpal tunnel syndrome is indicated by a numbness or tingling on the palm side of the first two fingers, part of the third finger, and the thumb. It is the damage to the median nerve that goes through the carpal tunnel.

The carpal tunnel is in the wrist. It is bordered on three sides by bones and on the fourth side by a strong ligament. None of these give very much. So when you use your tendons a lot, you get tendinitis or tenosynovitis. When you do that, things swell. When they swell in a confined space, they compress on each other. You get a circular problem in that the more they swell, the more they are damaged, the more they want to swell, the more they are damaged, and it keeps going around and around. It gets worse and worse.

The best thing to do is quit doing whatever you were doing that made it happen. It is like the dentist I went to one day. I said, "You know, my teeth hurt when I do like this," and he said, "Well, do not do that." It is the same way with carpal tunnel syndrome and all of these things.

If you back off and do not do whatever is causing it as much, frequently it goes away, and you do not have to end up in very expensive surgery. You do not have to end up disabled.

Raynaud's Syndrome

Third, Raynaud's syndrome, or occupational white finger, is a shut-down of the circulatory system. It is caused by exposure to vibration in the hands. I am not familiar with this disorder in the feet, but it might happen there. So segmental vibration or arm and hand vibration can bring this on.

I have not driven many tractors, but the ones I have driven vibrate. Old tractors are the only ones I have ever driven, because I do that kind of work you are talking about. I have a farm. I am a city boy, but I bought a farm. I have an old Ford tractor, and it does vibrate. There is a lot of vibration out there.

There is also non-occupationally caused Raynaud's syndrome. Some people get it without being exposed to vibration; mostly it is women who acquire it this way.

Let me go back—there are just a few of the agriculture-related cumulative trauma disorders. There are twenty-some repetitive motion related disorders of the upper extremities. There is rotator cuff, pronator teres syndrome, cubital tunnel syndrome, and epicondylitis. These are just examples. Do not get the idea that there are just a few of these disorders.

What do you do about cumulative trauma? First, I am getting the cart before the horse, but you have got to work on what is causing it, and so you work on the tools and the work station. Normally I deal with a fixed work station, and in agriculture that is not necessarily true. So the problem is more difficult to deal with.

We work on the methods: how people do their job, how they do the tasks. I put training and monitoring in there. It is hard to deal with changing behavior; because I do not have a lot of faith in training if it is easier to do something one way than the other.

I do not think we have a problem with work pace in agriculture, certainly not in the farming part of agriculture, maybe in other places. I am going to skip idle time; that is production-line-oriented.

RISK FACTORS

There are six risk factors that we look for in cumulative trauma.

Repetition

First is repetition, high repetition. If you are doing something highly repetitive over and over again, it tends to cause these problems. Repetition is rampant in things like processing of fish, meat packing, and luggage making.

Is high repetition present in farming? I do not know. I do not think anybody knows. My guess is that repetition is not where the major problem is.

At the other side of the curve, statically maintaining muscles causes problems. Statically loading muscles causes them to be exerted. They build up metabolic by-products. A lot of the time the circulation is cut off so that nutrients are brought into the muscles and the by-products are not carried off and you get rapid fatigue. Very static operations are a problem and very dynamic or repetitive operations are a problem.

High Force

The next factor, high force, is probably present in spades in agriculture, especially in maintenance-type things. Farmers and agricultural workers are notorious for ignoring good sense and picking up things they should not pick up. They exert high forces.

Things that require pinch grasp go along with that. Anytime you start using the tips of your fingers to exert force, you are not mechanically effective. It puts the body at a bigger disadvantage than normal.

So we have pinch grasp, we have static grasp, and what I call a press grasp, anytime you are pressing with hands. In industry when you are boxing things or when you are folding boxes or you are pressing down on tape, you start getting incidences of carpal tunnel syndrome. Those motions tend to be highly repetitive and with a press at the end of them.

Gloves cause problems. Gloves cause people to overexert for two reasons: they interfere with the grasp, and they interfere

with the feedback, so people tend to overgrasp. Gloves are worn a lot in agricultural work.

Posture

First, let us talk about shoulder posture. Anytime you are reaching down and behind or you are putting your elbow up in the air, you are doing something that a meatpacking company I have dealt with calls winging of the elbows. When they look at any kind of a task, they look for that. That causes problems with the tendons and the nerves.

Repeated inward and outward rotations, especially when you are going from the maximum of one to the other, is called pronation and supination. Inward and outward. Think about rotating the forearm. If you do that frequently, it causes problems such as cumulative trauma disorders.

When tasks are highly repetitive or are highly forceful and involve bending the wrist, they cause the tendons to wrap around a corner. They are pressing against those soft tissues that are supposed to lubricate their movement. Sometimes they press against the median nerve and do damage. We want to keep the wrist in a neutral posture as much as possible.

Mechanical Stress Concentrations Anywhere on the Skin

If you have somebody who has to maintain a pressure on the hand or anywhere else, it is a problem. Resting their arms on sharp edges or lack of a good armrest can cause nerve damage. It can cause circulatory or circulation damage.

If they use their hand as a hammer, like banging hubcaps on, banging things loose with the palm of their hand or the base of their hand, this causes nerve and circulation damage. Mechanical stress concentrations anywhere on the skin can cause problems.

A lot of the tools we use—pliers, screwdrivers, things like that—press right in the palm of the hand where you have the tendons and the nerves running, and they do damage.

Vibration

There are probably people in this audience who know a lot more about vibration than I do. We have whole-body vibration, and we have segmental vibration. Dealing with each is different.

The frequencies that cause problems are different. As far as I can tell in reading the literature, there is no good number as to what is excessive and what is not. There are some guidelines.

NIOSH put out a publication on this within the last year.[1] It is pretty good, but as far as I could tell there is no magic number that says, "When you start exceeding this number, you have got problems."

Cold

Now, when you throw in cold with any of these other factors, it accentuates it. When you throw in vibration with any of these other factors, it accentuates it. If you put cold in the environment and you get cold hands or cold muscles and tendons, it accentuates the problem. If you are doing some of these things and your body is vibrating, it accentuates the problem.

If any of you are familiar with industrial hygiene or familiar with chemical hazards, you know that OSHA sets permissible exposure limits (PEL's). Those are based on single-chemical exposures or single-agent exposures.

> She was telling me that the top occupational category suffering from tendinitis in the state of Washington is farmworkers.

No one knows what the combined presence of toluene, gasoline, and carbon monoxide does to you and at what concentrations that combination is a problem.

The same thing in ergonomics occurs. We have repetition here. We have force. We have posture. We have mechanical stresses. We have cold and vibration. All of these things combine in some way to cause problems.

One of the main questions I get is, "How many repetitions are too many reps? How much force is too much force?" We do not know because the problem is almost always in combination with something else. You cannot isolate them. We know that almost no force is required if the repetitions are high enough, because we have people that sign for the deaf that get carpal tunnel syndrome.

This is far and away the easiest to read and best book on cumulative trauma of the upper extremity.[2] It was originally put out by NIOSH, and it is now available from Taylor and Francis for about $23. There is an 800 number. They are located in Philadelphia.

WORK DESIGN

It seems to me in agriculture that we have a problem of work design. We have the task that people are doing. We have the machinery and equipment they are using. We have the products that they are producing and the products that they are using. All of these combine to be potential problems.

One of the things that I am interested in is packaging. Things that people use on the farm are packaged in anywhere from 5- to 100-pound quantities. I have seen people picking up 50-pound containers or 100-pound containers and standing in precarious situations and pouring them into hoppers or whatever.

It is no surprise that we have back injuries. It is no surprise that we have slips, trips, and falls. In fact, if these were in regular industry—if I were not working for OSHA at the moment—I would say, "OSHA might shut them down." It is hazardous.

RESEARCH NEEDS

I could not find data or anybody who knew of any data out there relating to cumulative trauma disorders, and there is not much relating to back injuries in agriculture, which I see as the number one research need. We have a dearth of data.

My understanding is NIOSH is beginning to act on this and that there are several programs. I think there are about three programs that may start to collect more data. I will admit that I may be ignorant of some of the data that has already been collected.

1. From my point of view, we need to determine the nature and the extent of the

problem. We also need reporting. It is my understanding that most farmers have never heard of an OSHA-200 log.

2. We are going to need epidemiological studies.

3. We are going to need studies on packaging and how to repackage things.

4. We need studies of what are the high-incidence tasks out there. Now some of them you know, but I would venture to say that if we ever arrive at cumulative data, if it is out there, we will find some tasks we do not know about now.

5. We also need to research what can be done in machine and equipment design to minimize cumulative trauma disorders, if that is what is causing them.

6. We need to figure out what the costs and the benefits are.

7. Lastly, and not necessarily least important, we have to come up with things that are acceptable to the people doing the work.

You know as well as I do that there is no more independent group than farmers. Maybe truck drivers challenge them, but farmers are very independent. You put guards on machinery, you do things that are supposed to be for their benefit, and they blow it off. We have to come up with solutions that are acceptable to this community.□

REFERENCE

Putz-Anderson, Vern; *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs*. New York: Taylor & Francis, 1988.

QUESTIONS

Ronald Schuler: I am from the University of Wisconsin, Madison. Dr. Cochran, have you heard of milker's knee, and is that a cumulative disorder?

Dr. David Cochran: I have heard of it. I am not familiar with it. My guess is yes, but I do not know. Tom, do you know?

Dr. Thomas Bean: It is very similar to miner's knee. It is a bursitis, an inflammation of the bursa of the joints, because of the constant bending, and the repetition, and the force as you are kneeling against the ground.

Dr. Wesley F. Buchele: I am Wes Buchele from Iowa State University, retired. Dr. Cochran gave a list of things you ought to conduct research on. I would like to add to that list, if I might, putting a screen over a wagon to permit people from sinking in the grain when they happen to be on grain. I happen to be one that thinks we should put extra seats on the tractor, with seat belts, because people are going to ride tractors and are going to have more than one person on the tractor. Therefore, we ought to start taking care of the problem as they do in Europe. I also think that we should think about putting floor boards on tractors to eliminate people being run over by tractors, which they are from time to time—run over by either a front wheel or a back wheel. We no longer put planters and cultivators in that area. I think we also ought to put a seat bar like on a ferris wheel or on forklifts. They have taken care of the forklift problem by putting a

seat bar on the skid steer loaders. We should have seat bars on tractors. We should also promote the use of guards by retrofitting. I think that we need to retrofit roll bars on tractors, guards on power take-off shafts, and guards on augers.

Mark Veazie: I am from the Johns Hopkins Injury Prevention Center. Dr. Cochran, have you done or are you aware of any assessments that have been done on cumulative trauma risk with manual harvesting typical of migrant and seasonal farm work?

Dr. David Cochran: I am not aware of any, but there may be.

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ELECTRICAL POWER

By Robert McLymore
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Dr. Glen Hetzel contributed a lot to this presentation, as well as some of my other colleagues. In the event that I did not call you to get some background information, do not feel bad. When they have the panel presentation tomorrow, you can answer some questions.

Electrical safety areas of concern are electrical wire components, electrical wiring systems, overcurrent protection, ground-fault interrupters, and grounding. These terms may not be important to you now. Maybe as you think in terms of what you do at your home, these terms can have some significance.

ELECTRICAL WIRING SYSTEM

The reason why I am talking about electrical wiring components is that we need to know where power is coming in on an operation.

We know that it is coming in several places—at the service entry riser and the meter. You may have a meter on your home. Think about it. There are meters on farms.

Farming is not like that picture that you saw—that poster—where you see them out in the fields smiling, laughing, carrying on, and having fun. It is much more. There is power somewhere on that farm: overhead power; there is underground power coming to that farm. It all has to go through a certain code.

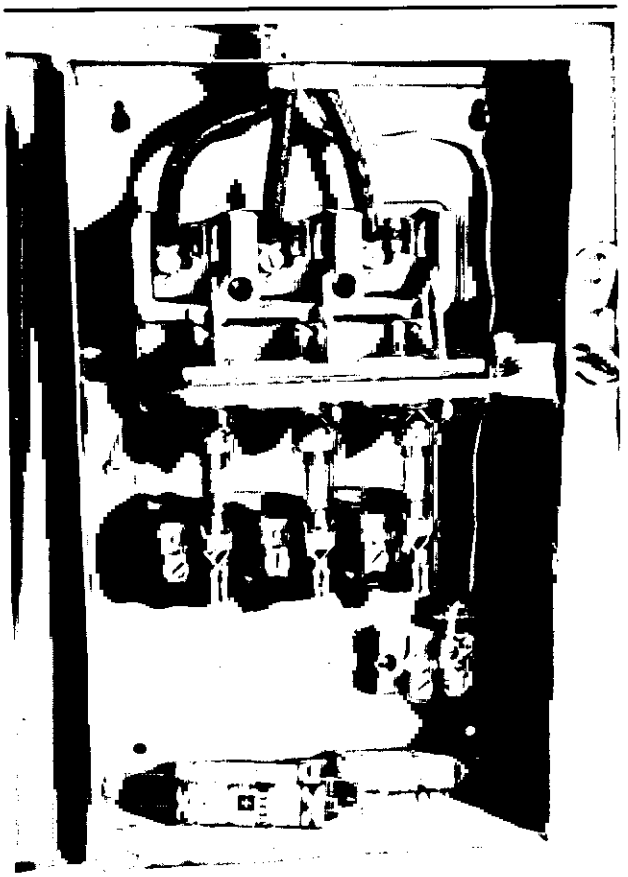

Figure 1. An Example of a Wiring Box.

For these components, you should only have licensed electricians install that electric wiring, and it has to be inspected. This may be what one of those wiring boxes looks like (Figure 1).

You have never opened one up, have you? You have never opened your fuse box up

at home, have you? It does not look like that. It has circuit breakers in it, has it not? This assures that the wiring will meet the requirements of the National Electric Code (NEC), as well as local safety codes, which may be in your home or in your state.

There are requirements for agricultural buildings in Article 547 of the NEC that specifies the type of materials to use for safety and protection is the environment in which this wire is contained. Dusty or damp conditions exist in agricultural buildings, which may create explosive atmospheres or corrosive conditions for electrical metal fixtures and equipment.

Did you ever think about that? These things, in themselves, may be explosive. That explosion may be in the form of a fire. That is what those conditions may be.

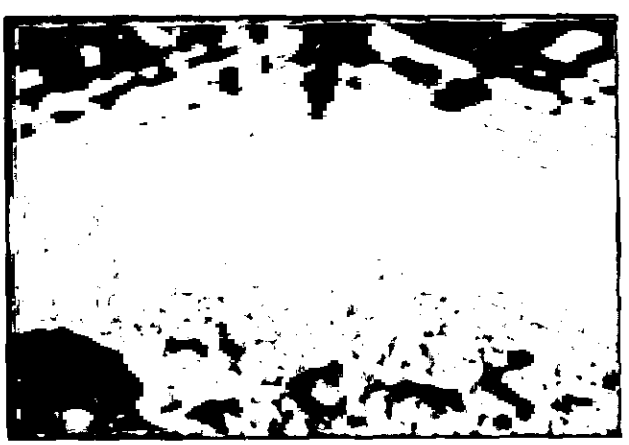

Figure 2. The Atmosphere of a Chicken Barn.

How many of you know about poultry. You ate it today at lunchtime. Was it good? Those are dusty, damp, dirty conditions—if you did not catch it in the last slide, that is what dust looks like when it is in suspension in the air (Figure 2).

This is what dust looks like when it is coming out of that vent that is adding air into that house (Figure 3). It is collecting particulate matter. Will that dust burn? Is it truly just dirt, or is there partially dry material in with that material?

OVERCURRENT PROTECTION

The next part is overcurrent protection. There are specific types of overcurrent devices. You have the plug, the cartridge fuses, and the breakers.

Figure 3. Dust on an air vent from a Chicken Barn.

Fuses

This is what they look like (Figure 4). There is the fuse (right, center in Figure 4). You have seen this type at home before, a screw-in fuses.

That is another type of cartridge fuse (also in Figure 4). Some are delayed so that when a surge of power goes through them—too much electricity—they are delayed. They protect the conducting wire.

You are probably more familiar with breakers in a box at home (Figure 5). The fuses and breakers are installed to protect the circuit, not the appliance.

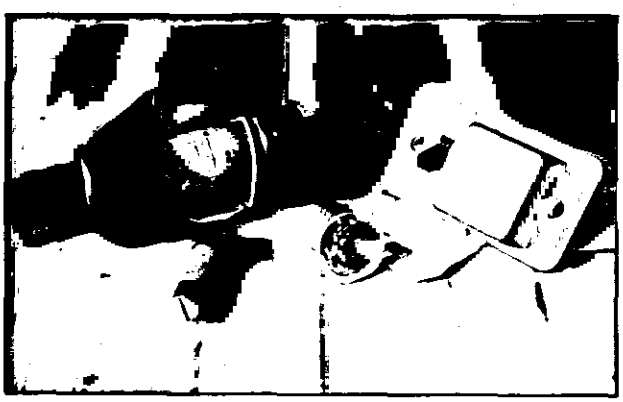

Figure 4. Examples of Fuses.

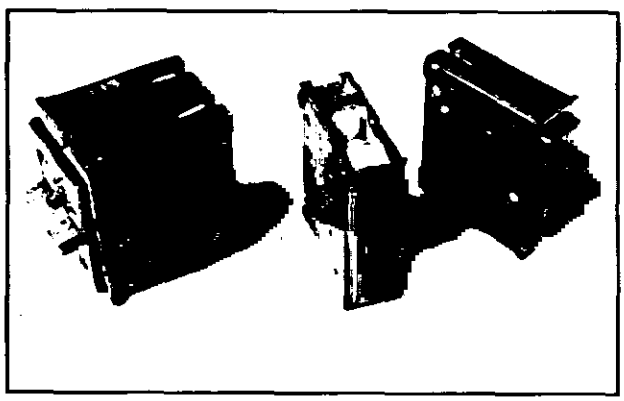

Figure 5. Examples of Breakers.

There are special fuses that are available to protect the electrical equipment, and it is important that we realize that overcurrent devices are sized to carry no more current than the circuit wire is rated to carry. Is that important to you? Is it important to that farmer?

Yes, it is important because he has some expensive equipment that he is using, and overcurrent protection is needed to protect it. What about for his own personal life? Think about you and the overcurrent devices that may be in your home.

You have wires like this that are made to carry a specific amount of electricity. If contact is made with a live part, will the overcurrent device trip and protect human life? No.

Well, I used to work at a funeral home, so I have seen it, too. The human body will receive a lethal shock if the current that flows through the body is 0.01 amperes or greater. A fuse or breaker will not provide protection to the human body. The wire protected by the proper size of the fuse or breaker will not allow the temperature of the wire to exceed safe operating conditions and cause what we have on some farms—explosions in bins and fires where material may be stored, like hay or dry feed.

GROUND-FAULT INTERRUPTER

The ground-fault circuit interrupter (GFCI). Are you familiar with that term? Do you know about it? You have seen it a lot? You buy devices, appliances, that have GFCI's on them. It is the most recent device that is used and designed to protect human life from shock.

It is designed to detect minute amounts of current, 0.005 amperes or greater leakage, from the circuit. It is supposed to trip the circuit off.

The overcurrent power and the conventional tripper turn the circuit off when there is a current flow that is in excess of the rated value of the breaker. The GFCI may be a separate device or it may be incorporated within a breaker. It is designed to give protection from that lethal

shock in a fraction of a second. It can be used on any 120-volt circuit.

It is also required in places at home by NEC. These places are in the kitchen, in the bathroom, in the garage, and exterior sockets on the house.

How many of you use extension cords outside to, perhaps, vacuum the car? Has the circuit ever tripped off for you when you were outside? Be thankful that they invented the GFCI. You would not be here at this conference without its protection.

Think about farmers. Are they always in dry locations when they are utilizing some of their appliances, some of their tools, like a skill saw or maybe a hand grinder?

There is one particular person who was using his welder when it was raining. He could not work outside, but he had some welding work that he needed to do.

He did not want to use the welder inside his shop because it was too small, too tight of an area, and there would be too many welding fumes. He laid down a piece of sheet metal; he pulled out the piece of equipment he was going to do some welding on, and he hooked it up to the welder.

The coroner tells us what happened to him next. He was shocked and killed. It was raining. There was the metal. There was the electrical appliance, with the electrical source coming in through the welder, and the welder was not properly grounded.

There are three types of and locations for these devices. We will find that these GFCI' scan be at a distribution box to protect the entire circuit or they can be at a receptacle box. They can also be in an extension cord.

GROUNDING

Do you see the third leg (Figure 6)? These are designed to give you continuity, to give you the grounding so that you do have a proper ground in that extension cord. That term "third-wire" ground and bonding should be understood for safety.

Electrical bonding means to connect all metal parts in the building together and that this be connected to the system of the ground.

The proper grounding of the system helps prevent stray voltage, which is a term that a lot of my colleagues know about. It is not voltage that wanders around aimlessly saying, "I am looking for a victim." It is voltage in itself that is not going to a proper ground. It provides a low resistance path for the neutral current to go to the ground.

That third-wire ground is the conductor in the wiring system that extends from the ground to the main distribution panel to the electric device and looks similar to that (shown in Figure 6). That is what is plugged in for your hot side and cold side. That is the ground that goes in. This is what it looks like on the other side, on the male side.

That is the female receptacle and the male receptacle (Figure 7). That is why bonding is so important—I talk about it twice because a lot of injuries and deaths could be avoided if the electrical bonding process was followed.

The last slides I have are getting more back to the topic of what to do from an

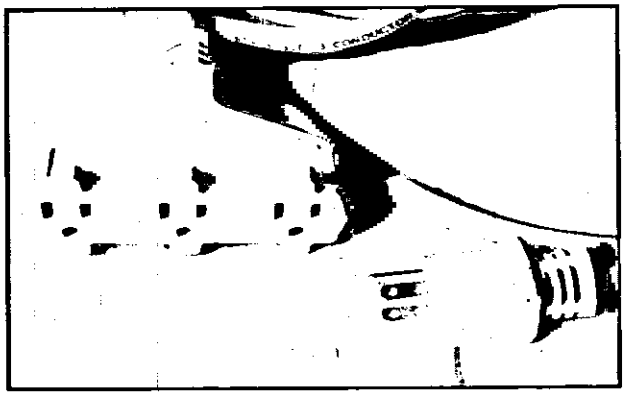

Figure 6. Example of Three-wire Receptacles.

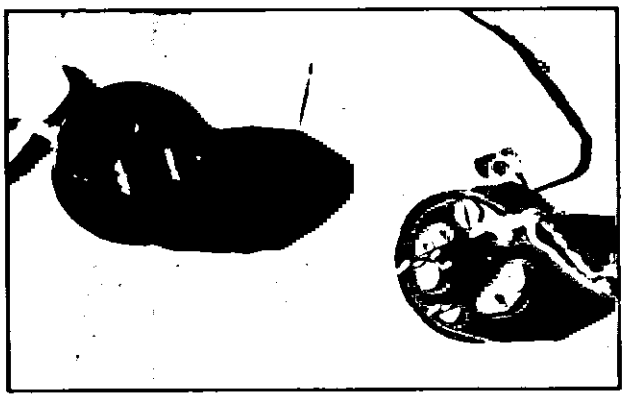

Figure 7. Male and Female Receptacles.

agricultural perspective, or even from just regular people's perspective.

GENERIC PROBLEMS

When you start thinking about your uses of electricity, there are generic problems I see that may arise on the farm.

Wire Damage

One is damaged wire resulting from crushing or cutting incidences where wire can be enclosed in a conduit material or exposed. In Figure 8, you see wire that is encased - either a metal case-like conduit or in the hard rubber, plastic, or the other material that you have that wire comes in.

When you are working around a farmplace, you are using a lot of equipment. Farmers are using equipment that backs onto it.

Two-Prong Adapters

These are what I call pseudo-outlets (Figure 9). These are two-prong plugs. The significance of these two-pronged plugs is that there are two-prong adapters being used with various equipment that requires that third wire ground, that third leg, so they can properly ground the electricity that is flowing through.

Figure 8. Examples of Wiring.

How many of you have remodeled your homes lately, or done anything inside the home where you changed a light fixture or maybe have changed a wall socket? They sell what I would term pseudo-outlets for you.

They were originally designed for two wire and replaced with a cover for a third wire

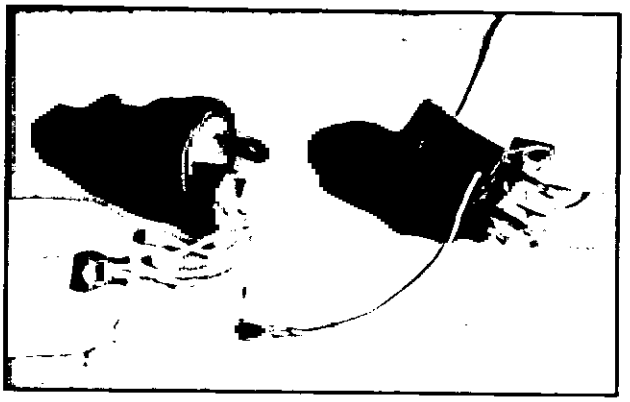

Figure 9. Two-prong Plug and Adaptor.

ground. It looks like it is grounded properly, but it is not. This is what it may look like (Figure 10). You have them there. Who is to say that has just been put into a two-prong outlet or through the wall socket. Assume it is not grounded unless you look behind it.

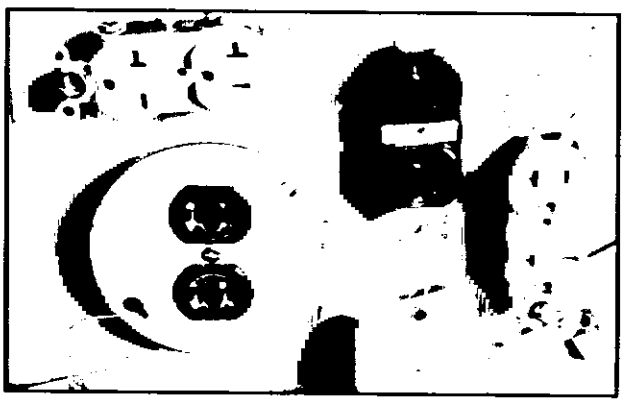

Figure 10. A Three-prong Receptacle.

Do you know whether or not it has been grounded properly? Can you tell? Can you walk up to and look at the socket and tell that it has been grounded?

That is why those 250 fatalities occur. Some of them did it before, some of them did not. This is a term which is not a scientific term, but I like it. Have you heard of a term called "shade tree mechanics?" This is what I call the "jack-leg" wire mechanic. That means that he is not following codes for the types of materials he uses. This is a faulty method of installation.

There is a hot wire that goes through the wire. There is a hot side and there is a cold side. You can hook the hot side through the switch and the cold side through the switch so the wire is running through the white side.

When you shut if off, the switch goes off, but it is still hot. You start working on that socket. You start taking it out of the wall to repair it; it is still connected. The power is still flowing through it. Was it installed using NEC codes?

Figure 11. A Wire Nut.

Wire Nuts

Some people, when they replace their wire nuts, do not necessarily use the wire cover on the nuts (Figure 11). They may use plastic. They may use tape. They may squeeze them together. But it may call for the wire cover, the wire nut, the yellow cap

to go over that wire where that connection has been made.

A lot of jack-leg wiring will go on like this. You have a conduit box there designed to carry only so many connectors inside. They are rated because of the amount of heat that is given off by each connector. They build up additional heat inside.

This situation is an excellent point for a fire to occur, unsuspectedly, for the wiring itself to degrade from the heat, causing it to touch the metal casing and the metal conduit around it. A person could then touch it and die.

Overhead Wires

I would be remiss without talking about what we traditionally think about on the farm where we have equipment that is being pulled around: getting in contact with overhead wires. There are labels. There are safety shields and warnings in place to help people to avoid that situation.

Most people, farmers and agriculture workers, do try to obey this. Sometimes, however, they get too busy, and they forget for a few moments. That moment of carelessness may end up with that piece of equipment getting in contact with that line. We know how electricity kills. It is going to go through what is grounded the most.

A cartoon character can live through it. The human body cannot.

CONCLUSION

Inspections Need to be Made

In conclusion, I would like to offer the following. Inspections need to be made on the farm. They need to be made on a scheduled basis and immediately when things are damaged. These inspections will reveal problems before they become life-threatening situations.

Those conduits, if they are bent, need to be checked. How many times have you put down an electric cord and said, "Well, I am only going to use this temporarily here; get some power to do this little function."

NEC Codes Should be Followed

Five years later you still have that same electric cord in place. Think about it at home. You have an electric cord you have been using someplace, have you not?

That moment of carelessness may end up with that piece of equipment getting in contact with that line. We know how electricity kills.

The NEC should be followed. It helps everyone on that farmstead or that place. They can have some assurance that there is some safety, that they know that it is supposed to be working like this. You know what kills a lot of people—things that "were supposed to be," (and were not) and sometimes we do not find out until after the fact.

Safety Procedures Adopted

There are safety procedures that should be adopted. First, if you are going to do your own work, you need to have someone there who can check it over before you start using it. What happens with people

doing their own work is that they are always trying to save on budgets.

Other problems are putting things up and not checking to make sure that they have been wired or that they have been grounded properly. Maybe someone cut down on the materials that are being used because he or she is just going to add some power to a particular room or building on the farm.

I have seen places where you have wires extended over here, hanging down—a light bulb extended hanging down from the rafter. That in itself is an accident waiting to happen. They can be avoided.

We are trying to get codes followed, inspections made, and safety procedures adopted. When you work with electricity outside, make sure that you do not use equipment unless it has been properly grounded with that third wire. Make sure that everything has been bonded together so that it is properly grounded. Only then can we address this problem effectively.□

Surgeon General's Conference on Agricultural Safety and Health
FarmSafe 2000 • A National Coalition for Local Action
Convened by the National Institute for Occupational Safety and Health
April 30 - May 3, 1991, Des Moines, Iowa

NOISE AND STRESS

By Matthew Marvel, M.D.
Attending Physician, Oneonta Health Center

It is indeed a privilege to speak to this dedicated and distinguished group. I appreciate being invited to speak here.

The topic of my talk today is noise and stress. Let me preview a little bit what I am going to talk about.

In a few words, I am going to be talking about noise and its potential to cause stress. I am not going to talk about stress to any great extent. Most of my expertise is in the area of noise and noise-induced hearing loss in farmers.

I am going to discuss those topics. For those of you who are not familiar with the subject, I am going to define noise and what constitutes dangerous noise.

I will be reviewing OSHA guidelines governing noise exposure, show some sample farm-equipment sound levels, and review the characteristics of noise-induced hearing loss. I am going to give an overview of studies that examined hearing loss in farmers and finish with suggestions for future research.

NOISE AND STRESS

First, a few words about noise and stress. Can noise cause stress? Yes. For example, if this microphone were to start having feedback, I think both you and I would start to have stress after a little while. There are ample studies in animals that have documented the ability of noise to cause stress-related physiological changes.

In humans, noisy jobs have been associated with higher rates of various diseases. Noise can cause stress by interfering with communication, disturbing concentration, and acting as a noxious stimulus leading to activation of neurohumoral mechanisms.

Noise results in elevated blood pressure, heart rate, and respiratory rate, as well as affecting other systems. All these contribute to increased levels of fatigue and, ultimately, injuries.

DANGEROUS NOISE

Noise is loosely defined as an undesirable sound. It is a subjective definition and one that is a matter of taste. For example, one man's noise is another man's music.

Potentially hazardous noise, on the other hand, can be simply defined as something greater than 85 decibels and is independent of the source. It is a function of the intensity, as measured in decibels, and of the duration of the sound.

This governs industrial workers and not, for the most part, farmworkers. It can be used as a guideline and should be used for farmworkers. After all, a hundred decibels in a factory is no different than a hundred decibels in a barn or in a field.

Where I am from, Ostego County in New York. Various types of equipment operate above this 85-decibel level. A cab added to a tractor can have a protective effect, on lowering the exposure to sound.

Chain saws are loud. Some people might find surprising their including chain saws on this slide, but in my part of the country particularly they are widely used on the farms, in wooded areas for clearing and for cutting firewood.

We have heard, at various times in the talks this week, how engineering is improving things for farmers. That is true in the area of sound production as well. Newer equipment is engineered to be quieter, but there is a lot of older equipment still in use. A survey of upstate New York found that the average age of tractors in use on farms is about 20 years. There is quite a bit of equipment out there being used that has not benefitted from this improved engineering.

NOISE-INDUCED HEARING LOSS

Noise-induced hearing loss can be either permanent (PTS stands for permanent threshold shift) or temporary (TTS refers to temporary threshold shift). Established noise-induced hearing loss is permanent, but moderate exposures to noise may cause temporary threshold shifts.

Repeated temporary threshold shifts may become permanent. Noise-induced hearing loss is sensorineural. In noise-induced loss, opposed to conductive types of losses that are due to middle ear disease, there is actual damage to the neurological structures of the inner ear. It tends to be bilateral but may often be directional, as some of the studies have shown. In addition, noise-induced hearing loss presents initially at higher frequencies, with a characteristic loss that occurs at 4,000 Hz. This is commonly called the noise notch.

This has implications for hearing conservation measures as well. Noise-induced hearing loss develops more rapidly at the higher frequencies, and speech comprehension is affected. Consonants are heard at the higher frequencies, whereas vowels tend to be in the lower frequencies.

It once was thought that speech was mostly a phenomenon that occurred between 500 and 3,000 Hz. The work of Alice Suter and others, however, has shown that accurate speech comprehension requires the perception of higher frequencies and that we need to be looking at those as well.[1]

STUDIES OF HEARING LOSS

I would like to now turn to the overview of some of the studies on hearing loss in farmers. It is not a large body of evidence at this point, compared to a lot of other fields.

Again, I am going to give an overview of the different published studies from the scientific literature covering hearing loss in farmers. The first reported study was by Glorig in 1957, who reported the results of hearing tests done on visitors to the 1954 Wisconsin State Fair.[2]

He found that farmers aged 50 to 69 had significantly more hearing loss in the 2,000 to 6,000 Hz range than office workers of the same ages. The frequencies affected pointed to noise-induced hearing loss as the culprit.

Lierle and Reger reported, in 1958, on the adverse effects of tractor noise on the hearing of farmers.[3]

The next reports did not appear until the mid-1970's, when Karlovich tested the hearing of an unselected rural population in Wisconsin[4], and Townsend studied a similar group in rural central Michigan.[5] Townsend used a mobile van to visit rural communities over an 8-week period and tested over 1,300 adults.

The purpose of the study was to depict a profile of hearing sensitivity of rural mid-western adults. His findings were that, on the average, hearing loss was greater than could be expected by aging alone.

There was no significant difference in hearing, however, between those with a history of industrial work and those without. He concluded that in addition to occupational noise exposure another noise exposure, perhaps recreational such as one gets during hunting, boating, or the use of snowmobiles, seemed to be a prime contributor.

Thelin re-examined what Glorig had found from the 1954 study to see if the discrepancy between the hearing of older farmers and office workers could still be shown and if there had been a change, and to determine if younger farmers were also at risk. The sites were the 1979 Missouri Farmer's Association Agri-Fair and the 1982 Shelter Insurance Health Fair.[6]

He tested 161 farmers and 75 non-farmers at the Agri-Fair and 130 office workers. His findings were that older farmers were still at risk for high-frequency hearing loss as were younger farmers, which Glorig had not found. Like Townsend, however, he also found a higher rate of hearing loss in non-farmers at the Agri-Fair. The non-farmers' hearing was not as bad as the farmers' but was worse than the office workers.

Karlovich, in 1988, published reports of his testing of 812 visitors over a 5-year period to the Wisconsin Farm Progress Days.[7] The purpose of this study was to re-evaluate the prevalence and characteristics of noise-induced hearing loss in a rural population. The findings were similar to the overall trends that Glorig had found in the 1950's.

Males continued to acquire noise-induced hearing loss sufficient to affect their ability to communicate. It was seen as early as age 20. One out of four of the males had the beginnings of a communication handicap by age 30; one-half of them had a communication handicap by the age of 50.

Again, both farmers and non-farmers demonstrated noise-induced hearing loss, suggesting a non-occupational source of noise like firearms use. Only 25 percent of noise-exposed males reported consistent use of hearing-protective devices.

Broste, et al., in a 1989 publication, examined an even younger group for evidence of noise-induced hearing loss.[8] He studied 872 high school students from Wisconsin to determine whether students engaged in farming had evidence for more hearing loss than their non-farming peers. He found that about twice as many students involved in farming had evidence of early noise-induced hearing loss as compared to non-farmers.

Less than one out of ten of the students, however, used hearing protection. The left ear was more severely affected, and for the first time in this series of studies, precautions were taken to exclude or to try to control for temporary threshold shifts.

I have a study that is due for publication this year. It will be appearing in the *Amer-*

ican Journal of Industrial Medicine.[9] We tested 49 randomly selected, full-time dairy farmers from Ostego County, New York.

Ours is the first study to examine a random selection like this. We also tested 49 age- and sex-matched rural non-farmers. The purpose of our study was to assess the prevalence and nature of hearing loss in this population.

Like Broste, we controlled for temporary threshold shifts, but we used hospital-based equipment. We found an alarming rate of hearing loss in the farmers, while the non-farmers had losses not far from what one might see due to the effects of aging alone. High-frequency ranges (HFA), is an average of the frequencies at 3,000, 4,000, and 6,000 Hz.

Sixty-seven percent of the farmers had abnormal hearing as opposed to 37 percent of the non-farmers, at the high-frequency ranges. The PTA4, which measured the mid-frequency ranges of 500, 1000, 2000 and 3,000 Hz, showed somewhat lower levels, but still a big difference. The farmers had a 37 percent rate of hearing loss, whereas the non-farmers had 12 percent.

As to the results of the subjects who were younger than the mean age of 43 years. At the higher frequencies, where we would expect to find noise-induced hearing loss, we saw lower average thresholds for the farmers.

We also found that the left ear was more severely affected, as did Broste. Through correlation regression analysis of the data, we were able to support our hypothesis that the differences found were due to farm noise exposure.

I am aware of one other study that is going to be published this year. The preliminary reports were presented at a hearing conservation conference in San Antonio. This is by {;alle, who is from northern Iowa.[11]

Looking at the troubles that some of the studies have had in separating occupational noise exposure from recreational, he sought to select a group of 30 farmers who had only occupational noise exposure. He compared them to a group of age-matched non-farmers who had no significant noise exposure. There were three groupings—age 30, age 40, and age 50.

The 30-year-olds had no significant difference at any of the frequencies tested. The 40-year-olds had significant differences in the 3,000 to 8,000 Hz range, again where you might expect noise exposure to start showing. The 50-year-old group had significant differences at all frequencies tested. I was pleased to find that his audiometric data looked similar to what I showed you on those two graphs. Our results look similar.

The cumulative summary of the findings, then, showed that farmers have higher-than-expected rates of hearing loss. This is true in all studies.

The rates exceed those of the general population, and loss starts in the teen years or before. Farm noise appears to be a major factor.

In addition, non-occupational noise may be contributing, as Thelin, Karlovich, and Townsend have reported. This is also something very important to recognize and address. If you are only working on occupational noise exposure and people are still losing their hearing while hunting, you are not gaining much.

That summarizes the studies that have been done to date. Despite the evidence, some people still have not heard the message. Therefore, more work needs to be done.

FUTURE RESEARCH

What are the areas for future research? First of all, we have barely scratched the surface of this problem. There is plenty of room for more research. The number of studies so far is still small, and it is a large and diverse industry with many different risks.

We also might find some high-technology solutions like using sound cancellation.

We ought to be testing other regions of the country, other types of farming practices, and other types of farmers.

Research should be done for more effective methods of hearing conservation and education. We should be doing dosimetry studies to better define noise risks. I was pleased in looking through the pamphlet showing the poster sessions. It looks like somebody is presenting something on that.

We need more research on the possible synergistic effects between noise and certain agents like carbon monoxide. We need some more research into engineering advancements, greater developments for quieter equipment at the source, ways to improve barriers to sound transmission like tractor cabs. This is needed not only for improved new ones, but perhaps more economical ones that farmers could retrofit.

We also might find some high-technology solutions like using sound cancellation. Improvements could be made in hearing protective devices, to improve the fit, the comfort and convenience and, consequently, the likelihood that farmers would wear them.

It would be nice to be able to better predict the risk of noise-induced hearing loss from noise exposure levels and early audiometric changes. Naturally, it would be good to see more basic science research into the anatomic, physiologic, and genetic bases for presbycusis and noise-induced hearing loss.

In conclusion, through research, let us continue to look for ways to better describe the nature of the problem so that through the spread of this knowledge those at risk for noise-induced hearing loss may see the ways to prevent it.□

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